THE MOTORCAR AND ITS STORY

CHARLES . R . GIBSON

F.R.S.E.

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THE MOTOR CAR & ITS STORY

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A MEET OF MOTOR-CARS IN 1904

In this picture of the Scottish Automobile Club, the costume of the members is almost as interesting as their antiquated machines.

THE MOTOR CAR & ITS STORY

A DESCRIPTION OF THE STRANGE VEHICLES INVENTED BEFORE THE MOTOR CAR, & THE STRUGGLES & ADVENTURES OF THEIR INVENTORS, WITH AN ACCOUNT OF THE EVOLUTION OF THE PETROL MOTOR CAR, & A SIMPLE EXPLANATION OF THE MANUFACTURE OF MODERN CARS & OF THE SCIENTIFIC PRINCIPLES ON WHICH THEY WORK

BY

CHARLES R. GIBSON, F.R.S.E.

AUTHOR OF
"SCIENTIFIC IDEAS OF TO-DAY," "WHAT IS ELECTRICITY?"
"ROMANCE OF SCIENTIFIC DISCOVERY,"
&c., &c., &c.

WITH MANY ILLUSTRATIONS

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PREFACE

THE subject of this book was suggested by two requests made to the author. The Council of a learned Society requested him to write a paper on the History of the Motor-car; and a group of army officers, resident in India, requested him to write a book on the Science of the motor-car. The present volume is an attempt to cover both these objects. There can be no doubt that there is a widespread desire to understand the science of things; some of the author's books, dealing with Scientific subjects, have been translated into Italian, Spanish, Dutch, German, Hungarian, Esthonian, Japanese, and Arabic. Also, this makes the thirty-fourth book which the author has written, so it is evident that the field is a wide one. It has been his endeavour in this book, as in all the others, to make the subject of interest to the general reader. It does not deal with the details of construction nor of the control of a motor-car; it is confined to the history and the science, and is intended to appeal to the general reader and the motorist in particular.

In tracing the evolution of the motor-car, the author has gone back, as far as possible, to the original sources of information, but much time

has been saved in research by Rhys Jenkins' excellent work (*The Motor-car*, 1902); being connected with the Patent Office he had ready access to all the best sources of information.

For the sake of those who may wish to go further into the subject a Bibliography is given in an appendix.

The author has dealt only with such matters as could be put in a readable form, leaving out a vast amount of detail. He has assumed that some readers have made no study of the subject, and in the chapters dealing with the science of the subject, he presumes no previous knowledge and avoids mathematics.

AUTHOR'S NOTE

THE author is indebted to the Rt. Hon. Lord Montagu of Beaulieu for perusal of some of his papers dealing with Roads, and to Mr. R. J. Smith, Secretary of the Royal Scottish Automobile Club, for particulars in connection with the early races. The author is very much indebted to the Librarian and Staff of the Patent Office Library, London, and to the Librarian and Staff of the Mitchell Library, Glasgow, for their very kind assistance in research work.

His thanks are also due to Mr. Rhys Jenkins and Messrs. Ernest Benn, Ltd., for permission to use material from *Motor-cars*, by Rhys Jenkins (T. Fisher Unwin, 1902), in the preparation of many of the line drawings.

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CHAPTER I

INTRODUCTORY REMARKS

THE reason for writing this book is given in the Preface, and I remark upon this as so many readers ignore the presence of the Preface.

In dealing with motor-cars, as with other things, we may say that *too much familiarity breeds contempt;* we have ceased to marvel at the motor-car. We are amused at the Chinaman, who, seeing a self-propelled vehicle for the first time, stopped, and, pointing at it, said, "No pushee, no pullee, go like mad!"

We would realise the marvel of the motor-car, were one of our great-grandfathers to return to Time and Space, and visit a busy street in any large city. The idea of the drivers and passengers sitting still and doing nothing to propel the cars would seem ridiculous to the old gentleman, who had been accustomed to the addition of a horse, or to being carried about in a sedan-chair. To dispense with the energy of horses or men would seem to be an impossible thing. Our ancestor would be surprised that we had become so blasé.

In the following pages it is proposed to trace the pedigree of the motor-car as far back as possible. An evolution is always of interest

provided a real connecting link can be shown at each stage, but interest ceases if the genealogical tree is traced beyond that, as I believe is the case with the orthodox pedigree of the steam engine, in which is included Hero's engine (100 B.C.); I doubt if there is any real connecting link. The ancestry of the motor-car can be traced back to Nicolas Cugnot's steam car, which ran in the streets of Paris in 1769; its speed was a slow walking pace, but it carried passengers, as we shall see later.

There were attempts to produce mechanically propelled cars at a much earlier date, and these will be mentioned without claiming for them any direct kinship with the motor-car. It is much less disturbing if there is an evolution and not a revolution in our methods of doing things. Much suffering was caused by there being practically no evolution in the case of the power-loom. The invention was worked out by one man—Rev. Dr. Edmund Cartwright, who was incensed by the laughter of some cloth manufacturers, when, at a dinner-party, he dared to suggest that some day we might have weaving-johnnies as well as spinning-jennies; Cartwright went home and invented a machine for the making of cloth. The whole affair came about so quickly that much hardship was caused to the hand-loom weavers, who could not hope to compete with this new rival. *It is an ill wind that blows nobody good;* the public reaped the benefits of cheaper production.

You may say that the evolution of the motor-car has been rapid, though not so rapid as that of the power-loom, and you may point out that it has caused hardships among the horse breeders, horse dealers, and carriage hirers; but the horse is still in evidence, and besides, we have had some time to readjust matters.

Petrol motor-cars appeared about the same time as Wireless Telegraphy, X-Rays, and Radium.

In order to remind readers of the position in 1897, I quote from a book of that date, *Motor-cars or Power-carriages for Common Roads* (A. T. Wallis):

"There can be little doubt that the vast majority of people would prefer a smooth-running, reliable steam engine for use as the propelling medium of a pleasure, or light business carriage to the evil-smelling, dangerous, wasteful, and at best uncertain and unreliable oil motor heretofore chiefly employed for that purpose in motor-cars of recent construction."

And again:

"At present it must be acknowledged that the success of the few motor-cars designed in this country (Great Britain) in the past, and the numerous ones more recently constructed abroad, have been only sufficient to show the feasibility of this kind of locomotion, and to encourage other attempts at their perfection, as all cars which have been built as yet, and are now on the market, are more or less unsatisfactory."

Those of us who put money into *The Great Horseless Carriage Company* should have been guided by the warning given in *Engineering*, 29th May, 1896 :

" The horseless carriage boom is going to afford a rich field for the operation of the professional company promoter in a veritable Tom Tidler's Ground for those ingenious but not over-scrupulous persons who exist and grow rich mostly by virtue of the credulity and greed of small speculators."

For the sake of any reader who may not happen to be acquainted with the expression *Tom Tidler's Ground,* I quote from Brewer's *Phrase and Fable :*

" The ground or tenement of a sluggard. The expression occurs in Dickens's Christmas Story, 1861. Tidler is a contraction of ' the idler ' or ' t'idler.' The game so called consists in this : Tom Tidler stands on a heap of stones, gravel, etc. ; other boys rush on the heap, crying, ' Here I am on Tom Tidler's ground,' and Tom bestirs himself to keep the invaders off."

Mention has been made already of the sedan-chair as a means of transport, and if the reader does not know, he may be surprised to learn that these were still in use so late as 1848. I find an entry in the *Glasgow Directory* of 1848–49 which reads : " John Sweenie, Sedan chair office, 23 Drury Street," which indicates the use of them in that year ; the name and office disappeared from the next year's directory.

The charges for the hire of a sedan-chair are given as under:

> Each lift of a sedan-chair in town, though for ever so short a distance, 6d.
>
> For waiting—first hour, 9d., thereafter 6d. per hour.
>
> Hire, 2s. per mile.
>
> Each person engaging a chair and not using it to be liable for the disappointment in 6d.

The sedan-chair is still within living memory.

It is not intended to consider early methods of transport further than to remark on the fact that some primitive methods exist till the present time, such as elephant and camel riding, and the man-power machine of Japan—the Jinrikisha.

In the following chapter it will be understood that no direct line of ancestry is claimed for the motor-car, but the methods of transport therein may be of interest.

CHAPTER II

CHAPTER II

BEFORE THE PEDIGREE COMMENCES

IT was natural that man should try to utilise the energy of wind, and so we find him trying to propel carriages by such means. The sailing chariot shown in Fig. 1 was built in Holland in 1600, and, according to the picture, it evidently went merrily along. It is said to have made a journey of 42 miles along the Dutch coast at a rate of 21 miles per hour, requiring only two hours for the journey. It carried, on this journey, no less than twenty-eight persons. According to the record, this trip was most successful, but we wonder at no further account being recorded.

Bishop Wilkins, in his *Mathematical Magic* (1648), refers to another form of wind-carriage, in which a sort of horizontal windmill is used (Fig. 2). He says: "I have often wondered why some of our gentry, who live near great plains, have not attempted anything to this purpose. The experiments of this kind being very pleasant, and not costly, what could be more delightful or better husbandry than to make use of the *wind* (*which costs nothing and eats nothing*) instead of *horses?*" But all Bishop Wilkins' suggestions were not carried out, for he shows in one illustration a man uprooting a heavy tree by blowing upon a little windmill which is so

geared, through a train of many wheels, to give a lift sufficient to uproot a tree. On making a calculation with the particulars which he gives for the gearing, I estimate the time factor to be about 600,000 years.

Another method suggested for utilising wind-power for propelling carriages was to use kites in tandem attached to the car by a long rope. This method was actually used in 1827, and a kite-carriage travelled from Bristol to London, and was frequently seen in Hyde Park. It is said to have travelled at a rate of 20 miles per hour.

Most of us have seen a horse-gin at work driving a threshing-mill at a farm; a car upon this principle was used by W. F. Snowden in London as recently as 1824. A drawing of it is shown in Fig. 3.

The carriage had an upper story for the passengers, and goods were stored on the lower floor, on which the horses walked round and round in order to turn the wheels by means of the gin.

Another idea (1829) was to use a horse to drive the wheels of a tractor, as shown on Fig. 4. The horse walked on a travelling platform, on which it made no forward progress. By this means the endless platform moved and turned the wheels. This was known as Brandreth's Cyclopede, but George Stephenson claimed the invention as his.

When the directors of the Stockton and

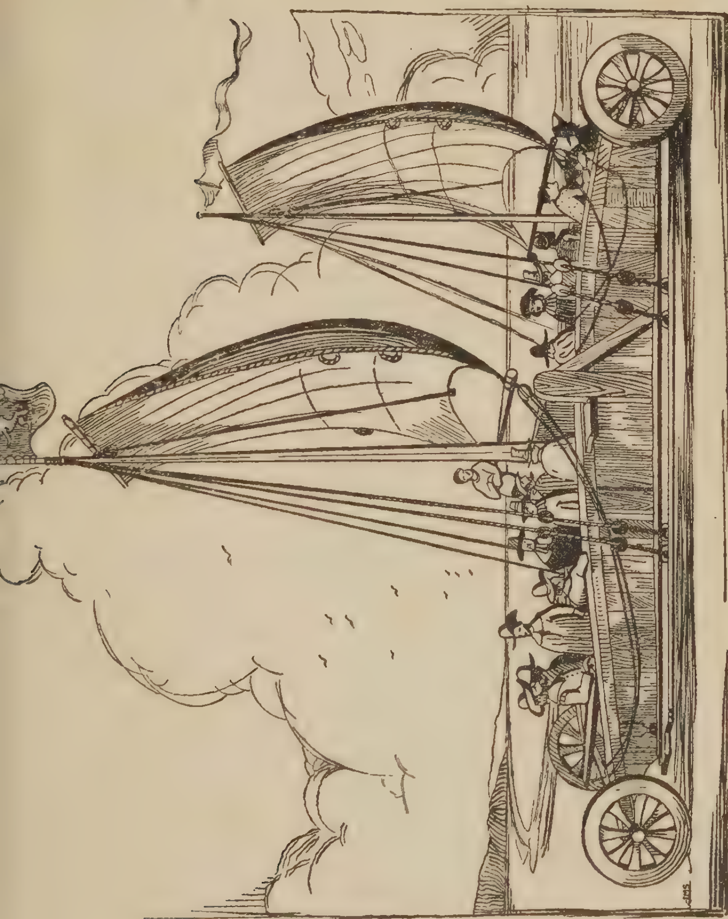

FIG. 1.—A 17TH CENTURY DUTCH SAILING CHARIOT.
This remarkable vehicle is said to have carried 28 people at a speed of 21 miles per hour.

Darlington Railway offered a prize of £500 for a locomotive, a horse-driven locomotive of this type entered into competition with the *Rocket*, the *Sanspareil*, and the *Novelty*, but it could not attain the necessary speed of 10 miles an hour; it reached from 5 to 6 miles an hour. One inventor of this type of locomotive claimed that

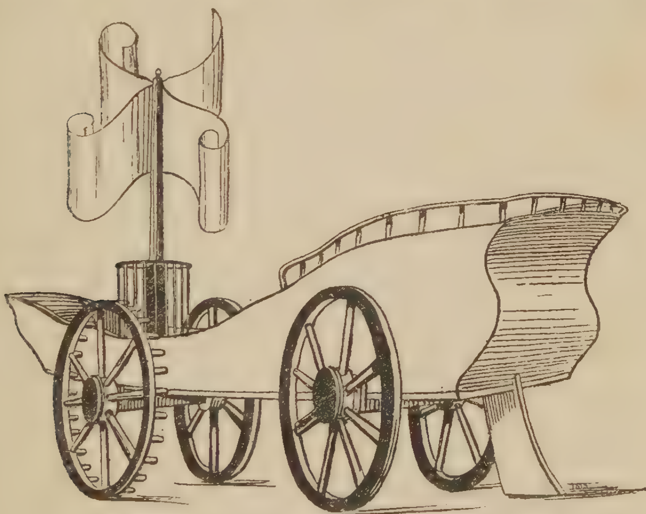

FIG. 2.—A WINDMILL CARRIAGE OF 1648.

it could travel 60 miles per hour, but when tried it was found that on short distances it could only reach 7 miles per hour; this was in 1850. Yet another early idea was to use coiled springs to drive carriages. One inventor even went the length of making a mechanical horse driven by springs, and covered with the real skin of a horse. He would not be able to ride far without rewinding the springs.

You may have heard of the Irishman who, when told that a certain clock would go for eight days without winding, asked how long it would go with winding. The springs in these carriages would require to be so heavy in order to store the driving energy, that they could not be very long, and the winding would be a real source of trouble, but in some cases this was done without stopping the car.

There are some early inventions using steam as the propelling force, but there does not seem to be any direct line of descent from these to the motor-car.

A Jesuit missionary (Father Verbiest), resident in China, where he became Astronomer-Royal at Pekin, made a model carriage which was driven by what is now known as Hero's engine. This was a metallic vessel partly filled with water, and subjected to the heat of a fire so as to raise steam which escaped from two horns on the sides, so placed that a rotary motion was imparted to the vessel.

Another early idea of producing a rotary motion is shown in Fig. 5 and was known as an Aeolipile, which name also included Hero's engine.

It has been said by some that Sir Isaac Newton invented or suggested the idea of a carriage to be propelled by the reaction of steam escaping from a jet, and pictures of Newton's steam carriage have been shown; this is a mistake, and it has been suggested that the mistake occurred through an author using the picture of such a

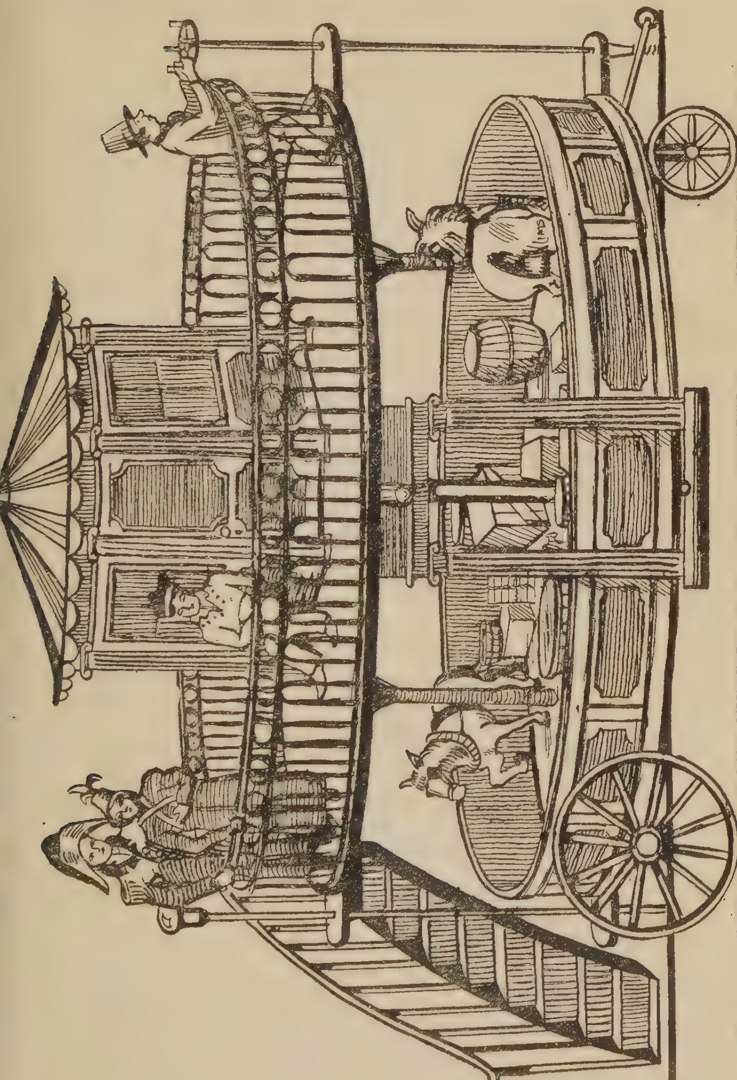

Fig. 3.—A Sumptuous Carriage.

W. F. Snowden used this enormous carriage in London in 1824. It was propelled by horses working a gin on the lower story.

carriage as an illustration of one of Newton's laws, and not as having been devised by him.

The next invention to be mentioned might

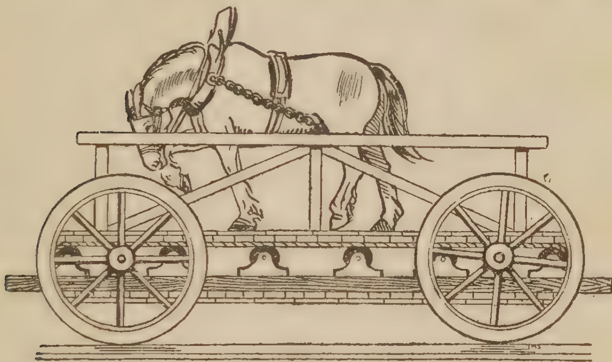

Fig. 4.—A Horse-driven Tractor of 1829.

almost be included in the succeeding chapter, but I am not sure that it is a direct ancestor of the

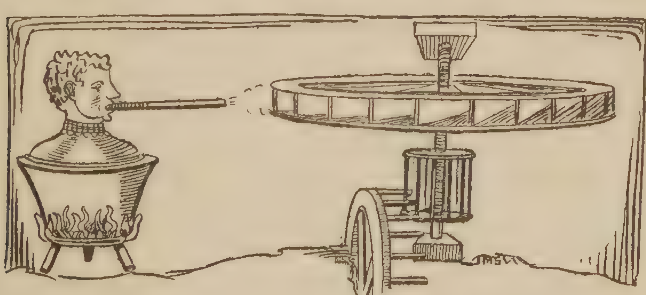

Fig. 5.—An Aeolipile.

Water was heated in an enclosed vessel and the steam resulting was caused to turn a mill-wheel.

motor-car, and it seems better to commence on the surer ground of Nicolas Cugnot's steam carriage, with which the next chapter will deal.

The invention to which I refer was made by a young French doctor, Denis Papin, who is undoubtedly the inventor of the first steam engine, which is a direct ancestor of the practical steam engine invented by James Watt. Our present interest in it lies in the fact that Papin applied his engine to a carriage, of which he made only a model; this was in 1698.

The idea of Denis Papin's engine was no doubt suggested by a gunpowder engine invented in 1680 by the Dutch scientist, Christian Huyghens. The principle upon which it worked was to explode some gunpowder inside a vertical cylinder while the piston was raised. The explosion forced the air out through a valve in the cylinder and a partial vacuum was produced beneath the piston, which was thereupon forced downwards by the pressure of the surrounding atmosphere. In moving downwards the piston pulled a weight upwards by means of a rope passing over a pulley. Denis Papin produced steam in the cylinder under the piston, and then by cooling the cylinder he produced a vacuum into which the piston was forced. Papin's engine was invented in 1690, which was eight years before he made his model steam carriage. Owing to the time necessary to heat and cool the cylinder, the action was a very slow one, and one is surprised that Papin applied such a slow prime-mover to a carriage, but he had no great hopes of success, although he was encouraged to further action by no less a personage than Leibnitz.

The statement that there is a real connecting link between Huyghens' Explosion engine and Papin's Steam engine is strengthened by the fact that the two men were acquainted with one another.

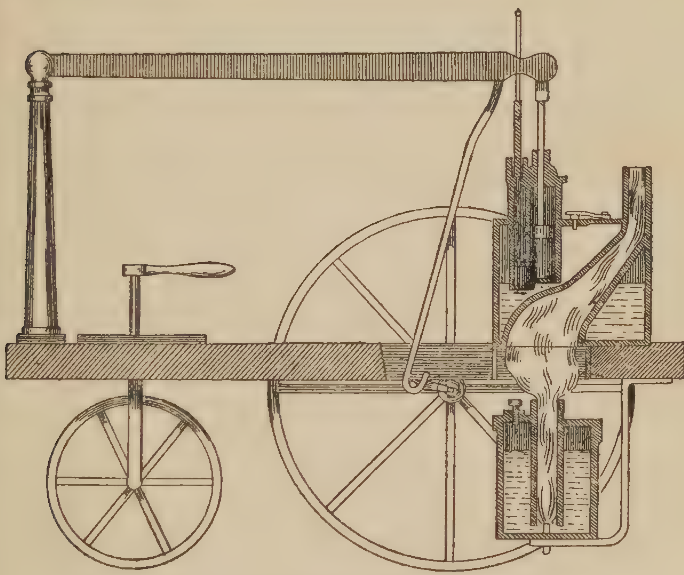

FIG. 6.—MURDOCH'S STEAM CARRIAGE MODEL.
This was the first application of Watt's engine to propulsion.

In passing, it may be remarked that the evolution of the steam engine from Papin to Watt is this :

Denis Papin boiled the water and condensed the steam in the cylinder.

Thomas Newcomen used a separate boiler for generating the steam, but condensed it in the cylinder.

James Watt added a separate condenser for cooling the steam, and used the expansion of the steam on the other side of the piston to drive it into the vacuum.

Watt's manager, William Murdoch, made a model of a steam carriage, and it is of interest as being the first application of a Watt engine to propulsion. Had an actual car been made I would have placed the invention in the succeeding chapter among the ancestors of the motor-car.

When Francis Trevithick was writing the life of his father, Richard Trevithick, in 1872, he made a journey to Redruth, Cornwall, where Murdoch had worked, and Trevithick got the following statement from the daughter of a clergyman, who was frightened by Murdoch's model when he met it on the road :

"One dark evening her parents, returning from Redruth to the vicarage, were somewhat startled by a fizzing sound, and saw a little thing on the road working in a zigzag way. Murdoch was with it; her parents knew him well. They understood that Murdoch wished the experiment to be kept a secret, and she does not recollect ever hearing of it afterwards, though she frequently saw Murdoch."

The full story of the clergyman and the steam carriage is given in the *Proceedings of the Mechanical Engineers*, 1850. The name is spelt Murdock, which was adopted by him on going to England ; this was to get over the difficulty the English people have in pronouncing "och."

"At the time Mr. Murdock was making his experiment with his locomotive engine he greatly alarmed the clergyman of the parish of Redruth. One night, after returning from his duties at the mine, he (Murdoch) wished to put to the test the power of his engine, and as railroads were then unknown (railroads were used in the early years of the seventeenth century, and were in use in Murdoch's day, but they would be of no use to the narrow-gauge model), he had recourse to the walk leading to the church, situate about a mile from the town. This was rather narrow, but kept rolled like a garden walk, and bounded on each side by high hedges. The night was dark, and he alone sallied out with his engine, lighted the fire or lamps under the boiler, and off started the locomotive with the inventor in full chase after it. Shortly after he heard distant despairlike shouting; it was too dark to perceive objects, but he soon found that the cries for assistance proceeded from the worthy pastor, who, going into the town on business, was met in the lonely road by the fiery monster, which he subsequently declared he took to be the evil one in *propriâ personâ*."

The incident is somewhat similar to the occurrence which took place when Fulton's steamship went along the River Hudson at night. Fulton's biographer tells us that when it breathed out flames and smoke, and defied the winds and the tide, the crews of the sailing ships were so alarmed that some of them took to their small boats and

pulled for the shore, while others fell upon the decks and prayed for protection against the approach of the horrible monster.

Although James Watt proposed a steam carriage he never seems to have tried it, yet it may be of interest to take a look at his proposal. He took out a patent for a steam carriage in 1784. The title of the specification (No. 1432) is *Fire and Steam Engines*, and I quote from it. It refers to a number of so-called improvements which are in reality different applications of the engine :

" My seventh new improvement is upon steam engines which are applied to give motion to wheel carriages for removing persons or goods or other matters from place to place, and in which the engines themselves must be portable."

He mentions " an artificial current of air produced by a pair of bellows or by some similar machine worked by the engine, or by the motion of the carriage."

From the particulars in the specification, I take it that this current of air was to cool the engine, just as we use a revolving fan to-day.

I mention this matter of the bellows as I find some writers giving a picture of Murdoch's model and calling it Watt's steam carriage.

I prefer to leave Watt's steam carriage out of the genealogical tree, as he did little more than take out a patent.

Letter from Watt to Boulton :

Birmingham, *Sept.* 12, 1786.

"I am exceedingly sorry that W.M. (*William Murdoch*) still busies himself with the steam carriage. In one of my specifications I have secured it as well as words could do it according to my ideas of it . . . it can scarcely be patentable. . . . I have still the same opinions concerning it that I had; but to prevent, as much as possible, more fruitless argument about it, I have one of some size under hand, and am resolved to try if God will work a miracle in favour of these carriages."

And again:

"Birmingham, *5th Oct.*, 1786.

"You know I have long had plans of moving wheel carriages by steam, and I have even described them in one of my patents some years ago. I believe I shall make some experiments on them soon, have small hopes of them ever becoming useful."

It is interesting to note that the idea of a steam-driven car was suggested to Watt by his friend Dr. Robison, who was then a student in the University of Glasgow, to which Watt acted as mechanic. This was at a date prior to Watt's steam engine, and before he got the University model of Newcomen's engine to repair, from which he derived the idea of improving a steam engine by the addition of condensers.

In closing this chapter it may be of interest to quote from a page of *Design and Work* of 10th

March, 1877, which I found among some old papers belonging to my mother:

"A new mode of travelling has been invented . . . which may be used whenever a sufficient velocity of current can be enclosed for a suitable distance. The device involves a carriage driven entirely by outside power; and paradoxical as it may appear, it is caused to travel either in the same direction as the force or diametrically opposite thereto, while the direction of the power remains unchanged. In short, it is a carriage which travels upstream, impelled by no other force than that of the current. The invention is claimed to be practicable; it has already been used in California for transportation on a small scale; and judging from experiments, the inventor states that a car for the transportation of passengers may thus be driven at considerable speed, depending of course upon the head of water."

"The carriage rests on ordinary flanged wheels, which traverse rails laid on the edges of the flume. On the axle are attached paddle-wheels, which correspond in shape to the section of the flume, and are acted upon by the current therein. It is clear that the current driving the paddles will so rotate the wheels of the vehicle, which will consequently move in a direction opposite to that of the current. When it is desired to move in the same direction as the current the paddles are stayed stationary and the water impels the car downstream."

CHAPTER III

CHAPTER III

EARLY ANCESTORS OF THE MOTOR-CAR

A DRAWING of Nicolas Cugnot's steam carriage is shown in Fig. 7, and it will be observed that the boiler is in front, and that the two cylinders drive a single wheel, which forms the third wheel of a three-wheel car.

It works on the principle of Newcomen's

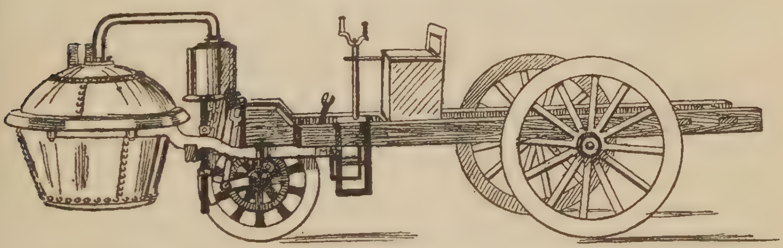

FIG. 7.—NICOLAS CUGNOT'S STEAM CARRIAGE.
This carriage ran in the streets of Paris in 1769, twenty years before Watt's engine came into practice.

engine, which is called an atmospheric engine, because the atmosphere pushes the piston into the vacuum as described in the preceding chapter. The term atmospheric is used to distinguish it from Watt's real steam engine, in which the pressure of steam operates the piston on the one side and the vacuum on the other side, the cylinder being then completely closed in.

Nicolas Cugnot's engine was necessarily a slow-acting affair, and we are not surprised to learn that the top speed of the car was somewhere about 3 miles per hour, so that a pedestrian could walk round it while it travelled. The average speed was $2\frac{1}{4}$ miles per hour.

It ran in the streets of Paris in 1769, which was twenty-one years before James Watt's engine came into practice (1790).

It was stated that Louis XV put State funds at the disposal of Cugnot to work out his invention, and as the king never had any excess of funds, which were spent in riotous living, we may presume that the invention was supposed to be of value from a military point of view.

The engine was worked by means of an automatic cock with four ways in it. When in one position it admitted steam into the first cylinder, and when in another position the cock allowed the steam to be exhausted, while a third way admitted steam to the other cylinder, and the fourth way was for exhausting it.

The power transmission was by means of two ratchet wheels and pawls, which were worked by the piston-rods. In order to reverse the carriage it was only necessary to change the position of the pawls so that they worked on the opposite faces of the teeth in the ratchet wheels.

There was no need of differential gearing as the car had only the one driving wheel (front wheel), which acted also as the steering wheel. It was necessarily an unstable machine, and we

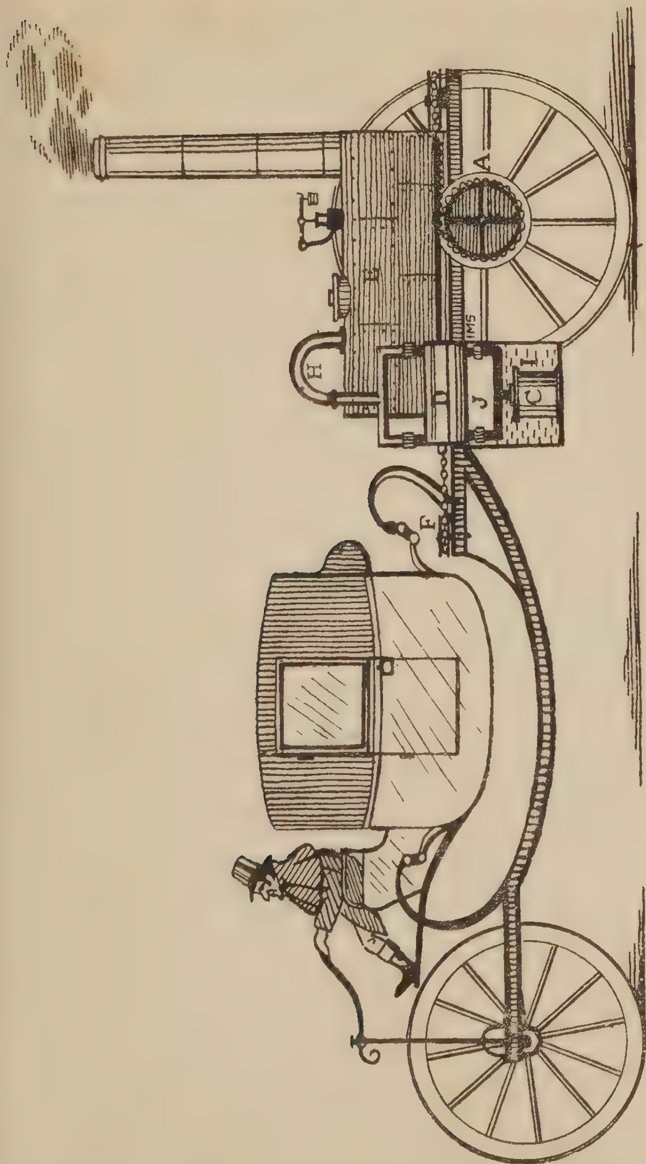

FIG. 8.—SYMMINGTON'S STEAM CARRIAGE MODEL.
In this model the wheels are turned by means of ratchets and chains.

are not surprised to learn that it was upset in the streets of Paris. The accident proclaimed it a danger, the inventor was imprisoned, and the car was forbidden further trials.

We have seen that the average speed was about half the pace of a man walking, but its progress was delayed further by the fact that the boiler required to be replenished every quarter of an hour, and for that a halt was necessary.

One of Nicolas Cugnot's original cars is still preserved in the Conservatoire des Arts et Métier, in Paris. There is a model of it in the South Kensington Museum, London.

It may seem to some readers that the steam carriage of William Symmington (Fig. 8) should have been included in the preceding chapter as only a model was made; the reason for placing it among the forbears of the motor-car is that great publicity was given to it. It was exhibited in Edinburgh in 1786, and it was the state of the roads in Scotland which prevented the inventor trying an actual passenger car.

William Symmington was born high up in the hills in Scotland, in the village of Wanlochhead. The idea of the steam carriage came to him before he had completed his twentieth year.

The next real step forward was made in 1801 by Richard Trevithick, and it is interesting to note that Nicolas Cugnot was still alive at that time; the date of his death being 1804.

Trevithick's steam locomotive (Fig. 9) is better known than his steam carriage, but the two things are quite distinct from one another; he invented the first steam carriage of a practical order as well as the first steam locomotive to run on rails.

The following are quotations which I make

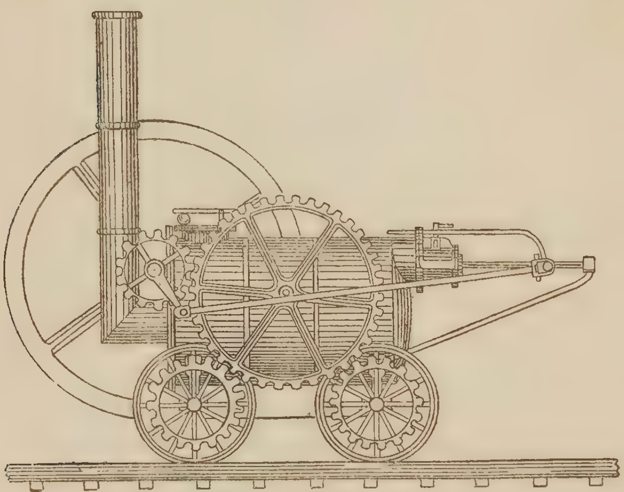

Fig. 9.—Trevithick's Locomotive.
This was the first engine to run on rails.

from letters collected by his son (*Life of Richard Trevithick* by Francis Trevithick, 1872).

Richard Trevithick constructed several model carriages in 1796; these were three-wheelers, but it was not till some years later that he made a carriage to convey passengers "moved by the force of steam" (Fig. 10).

"The start was from Tyack's smith-shop, where the smaller parts had been made. East and west ran the great main coach road to London, on which the Cornish coach, at that time a van or covered waggon, conveyed the few who travelled on wheels."

A friend of Richard Trevithick made the

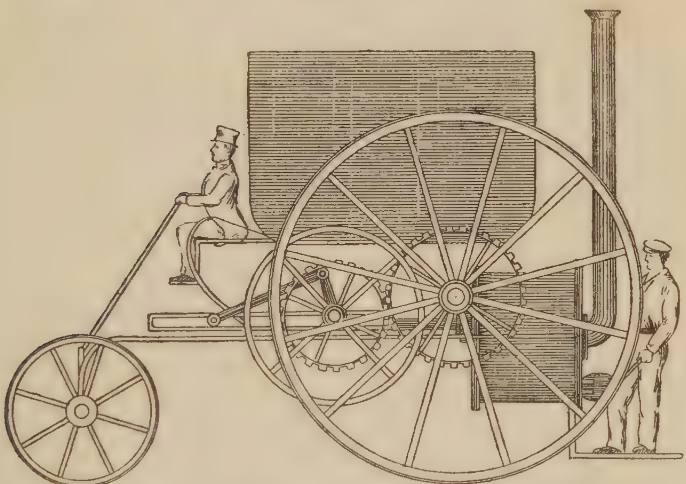

FIG. 10.—TREVITHICK'S STEAM CARRIAGE, 1801.
This carriage was the first self-propelled road vehicle of a practical nature.

following statement to the son, already referred to:

"I knew Captain Dick Trevithick very well; he and I were born in the same year. I was a cooper by trade, and when Captain Dick was making his first steam carriage I used to go every day into John Tyack's blacksmith's shop, close by here, where they put her together.

"In the year 1801, upon Christmas Eve, coming on evening, Captain Dick got up steam, out in the highroad, just outside the shop. When we see'd that Captain Dick was agoing to turn on steam, we jumped up as many as could, may be seven or eight of us. 'Twas a stiffish hill, but she went off like a little bird.

"When she had gone about a quarter of a mile there was a roughish piece of ground covered with loose stones; she didn't go quite so fast, and as it was a flood of rain, and we were very squeezed together, I jumped off. She was going faster than I could walk, and went on up the hill about a quarter of a mile further, when they turned her and came back again to the shop.

"Captain Dick tried her again the next day; I was not there, but heard that some of the castings broke. Recollect seeing pieces of it in the ditch years afterward, and suppose she ran against the hedge."

An old man, who was also a passenger in this early trip, said he could remember that Trevithick used a pair of bellows to blow the fire; bellows were in common use in those days.

The following is from a letter dated 2nd May, 1803, and addressed to Mr. Giddy by Mr. Trevithick himself:

"The coach engine did not arrive in London until last Wednesday. The coach is ready to fix to the engine. I expect we shall be ready to start in a fortnight. . . . I have a prospect

before me of doing exceedingly well. I tell you, as a friend, that I have sold to a gentleman of this place (Bristol) one quarter part of the patent for 10,000 L; but this must remain a secret."

Writing again to the same gentleman on 20th February, 1804, Trevithick says:

"The tram waggon has been at work several times. It works exceedingly well, and is much more manageable than horses. We have not tried to draw more than 10 tons at a time, but I doubt not we could draw 40 tons at a time very well; 10 tons stand no chance at all with it. We have been but two miles on the road and back again, and shall not go further until Mr. Homfray comes home. He is to dine at home to-day, and the engine goes down to meet him. The engineer for the Government is with him. . . . The public are much taken up with it. . . . The steam that is discharged from the engine is turned up the chimney about 3 feet above the fire. . . ." (George Stephenson is often credited with the invention of the forced draught by means of the exhaust steam.)

"The fire burns much better when the steam goes up the chimney than when the engine is idle. . . . We shall continue our journey on the road to-day until we meet Mr. Homfray and the London engineer, and intend to take the horses out of their coach, fasten it to the engine and draw them home."

In another letter dated 22nd February, 1804,

and writing to the same gentleman, Trevithick says:

"Yesterday we proceeded on our journey with the engine; we carried 10 tons of iron, 5 waggons, and 70 men riding in them the whole of the journey. It is above 9 miles, which we performed in 4 hours 5 minutes." (This would appear to give only a speed of $2\frac{1}{4}$ miles per hour, but the succeeding sentence of the letter explains matters.) "We had to cut down some trees and remove some large rocks out of the road. The engine when working went nearly 5 miles per hour; no water was put into the boiler until we arrived at our journey's end. . . ." It will be remembered that the boiler of Nicolas Cugnot's carriage required to be refilled every quarter hour.) . . . The gentleman who bet 500 guineas against it rode the whole way with us, and is satisfied that he lost the bet.

"The public until now called me a scheming fellow, but now their tone is much altered. Watt and Boulton have strained every nerve to get a Bill in the House to stop these engines, saying the lives of the public are endangered by them, and I have no doubt they would have carried their point if Mr. Homfray had not gone to London to prevent it, in consequence of which an engineer from Woolwich was ordered down, and one from the Admiralty Office, to inspect and make trials of the strength of the materials.

It is evident that the quotations on this and the preceding page refer to the locomotive.

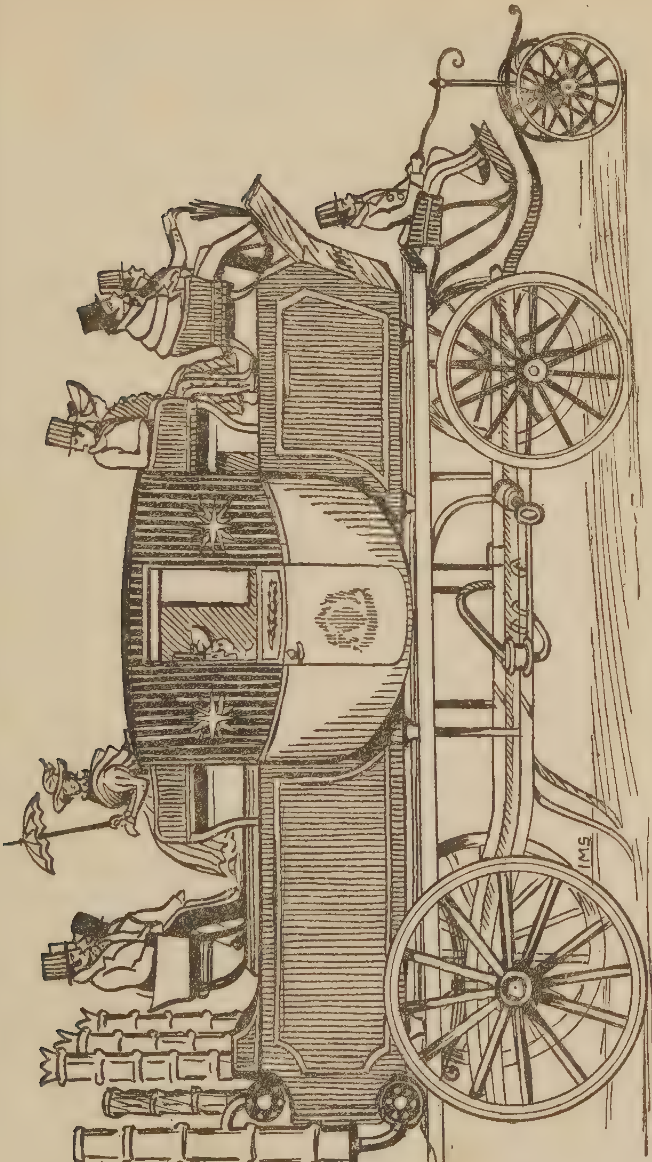

FIG. 11.—GURNEY'S STEAM COACH, 1829.

This coach covered the double journey from London to Bath and back, at a speed of 15 miles an hour.

The following quotations are made from a statement by John Vivian and refer to the steam carriage:

"The carriage for the passengers would hold eight or ten persons, and was placed over the engine, on springs. One or two trips were made in Tottenham Court Road and Euston Square.

"One day they started about 4 o'clock in the morning and went along Tottenham Court Road and the New Road or City Road (now Euston Road); there was a canal by the side of the road at one place, for he was thinking how deep it was if they should run into it. They kept going on for 4 or 5 miles, and sometimes at the rate of 8 or 9 miles per hour. I was steering, and Captain Trevithick and someone else were attending to the engine. Captain Dick came alongside of me and said, 'She's going all right!' 'Yes!' said I, 'I think we had better go on to Cornwall.' She was going along 5 or 6 miles per hour, and Captain Dick called out, 'Put the helm down, John!' and before I could tell what was up, Captain Dick's foot was upon the steering wheel handle and we were tearing down 6 or 7 yards of railing from a garden wall. A person put his head from a window and called out, 'What the devil are you doing there? What the devil is that thing?'

"They got her back to the coach factory . . . I heard afterwards that the framing of the engine got a twist, and she was used to drive a mill for rolling hoop-iron; also that she ran on a tram-

road rail down in Regent Park." (It will be observed that it was a tram-road rail: this carriage could not run on a railway track as did Trevithick's later locomotive. See Fig. 10.)

More Steam Carriages

During the years from 1821 to 1840 there was built a great variety of steam carriages, so many that only a few of the outstanding ones can be mentioned here without risk of wearying the reader.

One well-known set of coaches was called Gurney's steam carriages (Fig. 11), the owner being Sir Goldsworth Gurney, who began experiments in 1823.

While a schoolboy he had seen Trevithick's steam coach making trial runs. Gurney was the inventor of the oxy-hydrogen blow-pipe, he also discovered the limelight used in magic-lanterns.

In February, 1829, Gurney made a journey with his steam carriage from London to Bath and back again, travelling at the rate of 15 miles per hour. The double journey was a distance of 212 miles. The journey was undertaken at the request of the quartermaster-general of the army, and was the first big journey made at a maintained speed.

Another well-known set of steam carriages was invented by Walter Hancock, who in 1824 invented an extremely curious steam engine. There was no cylinder and no piston; merely two

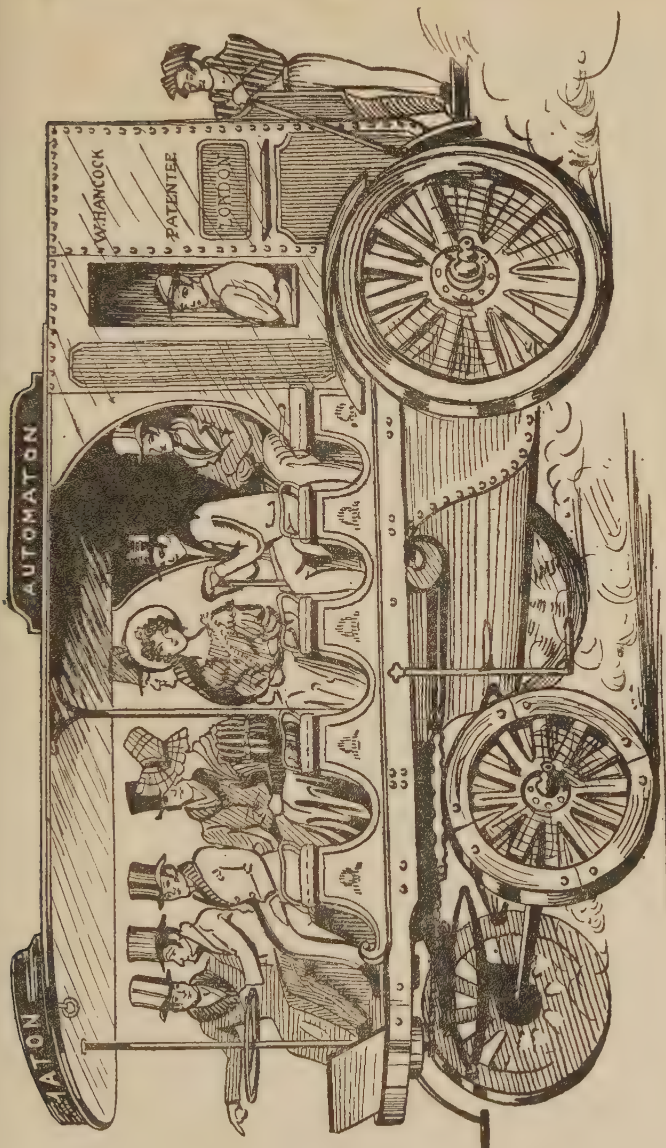

FIG. 12.—HANCOCK'S AUTOMATON.

This coach ran for three months on a regular route along the Paddington Road, carrying many passengers. It proved to be quite reliable.

flexible bags, which were alternately filled with steam. The motion was got by the expansion and exhaustion of these bags. Hancock tried to apply this engine to a carriage, thinking it specially suitable because of its lightness, but it did not prove a success. However, it was this curious beginning that led him to success with piston and cylinder engines on carriages. He invented many steam carriages, and one of these, named the *Automaton*, is shown in the accompanying drawing (Fig. 12).

This coach ran on the Paddington Road for about three months, covering a total distance of 4200 miles, and carrying in all 12,761 persons. He offered to carry the mails at 20 miles per hour.

The Steam Carriage Company of Scotland, in 1834, established a line of steam coaches between Glasgow and Paisley. These coaches were built at Edinburgh by John Scott Russell, who was an engineer, born at Parkhead, Glasgow. He studied at the Universities of Glasgow, Edinburgh, and St. Andrew's. He became manager of Caird's Shipbuilding Works at Greenock. While a shipbuilder on the Thames he built the *Great Eastern*. Strange to say the *Dictionary of National Biography* makes no mention of his connection with steam carriages. In the Scott–Russell carriages the rear wheels were driven by spurwheels on the axles. The coaches were very popular, but, unfortunately, one accidentally ran over a heap of stones and was overturned, causing the boiler

to explode, by which a number of passengers were killed. The Court of Session then interdicted the use of these carriages.

In addition to a multitude of steam carriages there were others driven by compressed air. The air was carried in cylinders under high pressure (1000 pounds per square inch and over). The idea of compressed air carriages began as far

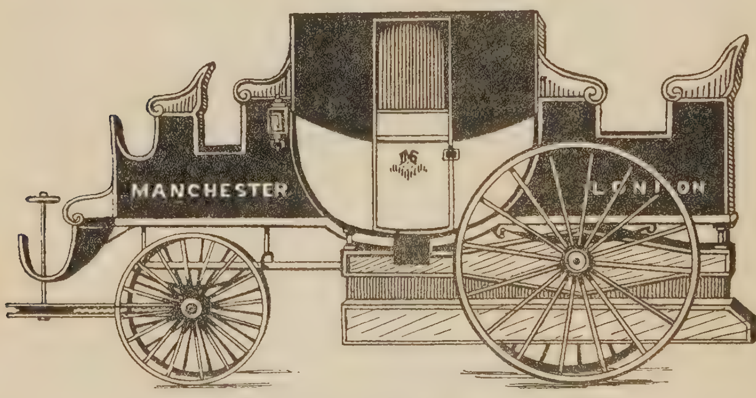

FIG. 13.—MANN'S COMPRESSED AIR CARRIAGE.

back as 1799. The inventor was George Medhurst, of London, who also invented the pneumatic despatch system.

There were several other inventors of compressed-air carriages, one of which is seen in Fig. 13. The inventor of this carriage was William Mann, who had such great faith in this system that he advocated a public supply of compressed air. Such a supply was given in Paris.

Steam carriages continued to be built in 1872, when Mr. Charles Randolf (*partner with Mr. Elder in the famous engineering firm on the Clyde*) ran one of these carriages in the streets of Glasgow. It is said: "He found no difficulty whatever in threading his way through the most crowded parts of the city, and in the busiest time of the day, and that without causing any trouble or annoyance to himself or the public; on one occasion only did he notice a horse to be frightened."

One is surprised to find that the electrically driven carriage dates back to 1839, while the self-existing dynamo was not invented until 1871. The electric motor must have consisted of an electro-magnet attracting bars of iron. From the description of the car these seem to have been mounted on a wooden cylinder or drum, and there would be some simple make and break arrangement, such as a star wheel by which the electric current might be switched on to and off from the electro-magnet. I have seen old toys made upon such a principle, but the driving power is erratic and is not great. The inventor was Robert Davidson, of Aberdeen, who, after trying his electric carriage "on a rough floor," converted it into a locomotive to go on rails, probably to get rid of the surface friction of the floor which it would have difficulty in overcoming, and so our present interest in it ceases. The carriage is said to have been capable of carrying two passengers. There were other attempts at electrically driven

vehicles, but these were chiefly confined to railway locomotives, so we may pass on to a date at which such vehicles had a chance of becoming efficient with what we now know as an electric motor. Ten years later than that there was a great improvement made in accumulators (1880). In 1882 two men well known to many of us, Professors Ayrton and Perry, made an electric tricycle, using a gear wheel on the motor shaft and another on the driving axle, giving a direct drive. Not many years ago I found a lady with a petrol motor directly geared to a tricycle, but I managed to dissuade her from using it unless she could get some clutch arrangement introduced; she then got a motor-car. The Ayrton and Perry tricycle was interesting from a scientific point of view, but not from the commercial side.

In 1887 an electric cab was seen in the streets of Brighton; it was belt-driven, and was constructed by Radcliffe Ward. It had an intermediate shaft with two loose pulleys so that the power might be transmitted through either of these and thus give two different speeds, the pulleys being of different sizes. In this we can see the germ of a gear-box. The two change-speed wheels were brought into play by means of clutches. This electric carriage attained a speed of 8 miles an hour. The inventor next turned his attention to an electric omnibus, which travelled over 5000 miles on the London streets at a speed of 7 miles per hour.

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HANCOCK'S STEAM-COACH, "ERA." 1833

Between the years 1824 and 1840, Hancock built eight or ten steam vehicles and covered many thousands of miles with considerable reliability. The constant opposition of Turnpike Trusts, bad roads, and bad laws, and lack of public recognition of his work finally discouraged him, but he remains one of the most successful of the early experimenters.

Another inventor, also in Brighton, made an electric dog-cart which became well known in the town. In 1888 this inventor built a similar electric dog-cart for the Sultan of Turkey, but there is no record of its behaviour in the Ottoman Empire.

In 1893 an electric phæton was built capable of carrying six passengers, and in 1894 a four-wheeled vehicle was built. In the same year an electrically driven parcels van ran in the streets of Dundee.

It is interesting to note that in the Paris-Bordeaux Competition of 1895 an electric carriage was among the competitors, and it covered 350 miles with frequent relays of accumulators; these would have to be changed every 40 to 50 miles.

An American invented an electric carriage in which he dispensed with the need of a differential gear by having an electric motor to drive each wheel independently.

In 1897 electric cabs appeared in the streets of London, and by that time a beginning had been made with petrol motors, which will be considered in the succeeding chapter.

CHAPTER IV

CHAPTER IV

THE PETROL MOTOR-CAR

THE invention of the internal combustion engine or explosion engine gave a beginning to the modern motor-car; there was no longer the necessity of carrying about heavy boilers and heavy steam engines.

As is well known, the inventor of the petrol motor-car was Gottlieb Daimler of Wurtemburg who had assisted Otto in perfecting his gas engine. These engines were undoubtedly direct descendants of Huyghen's gunpowder engine, to which I have already referred.

In 1800 Medhurst took out a patent for an engine to be worked with gunpowder or other explosive, and he proposed to apply this to a carriage. In 1862 a gas engine was fitted to a carriage by the French engineer Lenoir.

In 1880 there was an interesting development. Lawson invented a gas engine driven by the explosion of gasoline vapour. This gas motor was used to drive a tricycle which carried a store of gas with it.

This was followed in 1883 by other two inventors who not only made a gas motor-cycle but took out a patent for the use of petroleum

spirit for working it. Then came Daimler's petrol motor, which at first was of little interest to this country (Great Britain) because of the Act of Parliament referred to in the succeeding chapter. The inventor appealed to France, which was free from the ridiculous restrictions imposed in Great Britain, and all credit is due to France for bringing the motor-car into practical use. There is no doubt that the wide use of the bicycle as a means of locomotion on the highways helped to prepare the way for the motor-car.

In 1885 Daimler invented his engine to be worked by gas or petroleum vapour or spray. Like the Otto gas engine, it was a four-stroke engine; at one downward stroke it took in the gas-and-air mixture, at the next upward stroke it compressed the gas mixture, when the explosion occurred driving the piston down again, and the momentum of the fourth and upward stroke dispelled the burnt gases.

At first Daimler applied his engine to a bicycle (Fig. 14).

It will be observed that Daimler used a bicycle of the old bone-shaker style, at which one is surprised. It was belt-driven, and the engine was placed vertically beneath the rider's seat.

The clutch arrangement consisted of a jockey pulley, which tightened or loosened the belt, and was worked by a small handle in front of the rider. When the band was slackened to dis-

connect the drive, a brake was automatically applied to the rear wheel; there were no pedals.

The speed of the engine was governed by preventing the opening of the exhaust valve when speed was above the normal; the cylinder, being

FIG. 14.—DAIMLER'S MOTOR BICYCLE.
This bone-shaker was the foundation from which the modern petrol-driven car grew.

full of gas, prevented any fresh gas being drawn in, so that there was no explosion.

The exhaust was used to warm the carburettor through which the air bubbled and thus produced the explosive mixture. It was not till 1893 that this bubbling carburettor was replaced by the well-known present form with a float-feed spray.

The next advance was a four-wheeled motor-car constructed by Daimler. Instead of the engine being in front, it was placed with its cylinder standing up through the footboard of the rear seat, in order to be near the driving wheels; this did not prove a success.

In 1885 Carl Benz, of Germany, built a three wheel motor-car in which the engine was placed behind the seat and well above the rear axle. The engine was driven by the vapour of benzine. The flywheel was placed in a horizontal position, the crankshaft being vertical. A short horizontal shaft was geared to the upper end of the crank-shaft by bevel gearing, and there was a counter or intermediate shaft placed under the floor of the car. On this shaft there was a fast-and-loose pulley which took the place of a clutch, the engine being allowed to drive the loose pulley when the car was at rest. The handle for shifting the belt from the fast to the loose pulley also applied a brake when running on the loose pulley. The engine was water-cooled, having a water jacket.

In the following year he built another car into which he introduced a variable speed device, and the brakes were arranged so that they could not be applied until the engine was running free. The supply of gas was automatically reduced when the engine was running free, this was worked by the clutch lever working a stop-cock. The speed was about 10 miles per hour, but a third car reached 15 miles per hour.

One of the earliest makers of motor-cars was the firm of Panhard and Levassor, of Paris. They acquired the French and Belgian rights of the Daimler petrol engine. They had an engineering business, and their first idea was to use the petrol engine for industrial purposes. They adapted it also to launches before they attempted using it on a car, but in 1891 they brought out

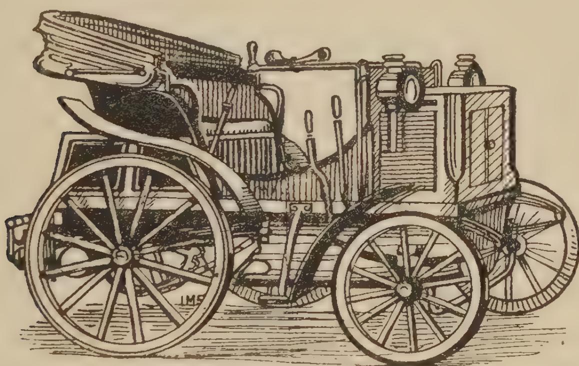

FIG. 15.—AN EARLY PANHARD CAR.
These cars had Daimler engines of about 3 horse-power. They were water-cooled and chain-driven.

quite a nice-looking car, and it was soon followed by other ten cars. By the end of three years they had built no less than ninety cars and three hundred and fifty engines.

The car engines were very small, being about $1\frac{1}{2}$ horse-power, and the three gears were such that they gave speeds of 3, 6, and 10 miles per hour. These cars were the first to have the engines placed in front, chains being used to transmit the power to the driving wheels.

It will be of interest to consider the general principle of a car of 1894. Panhard and Levassor entered four cars of the following type for the Paris-Rouen contest of that year. Of course, they had Daimler motors, the power being about 3 horse-power. The engines were placed in front of the car, and the cylinders were water-cooled. The car carried two petrol tanks, a small one in front holding about 1½ gallons and a large one behind holding about 5 gallons. The distance travelled was from 30 to 35 miles per gallon.

It is interesting to note that by this time the crankshaft was placed lengthwise, as is still the practice, and this was coupled by means of a friction clutch to another length of shaft in line with it. There was a shaft above this one, and at right angles to it, carrying the change-speed gear and sliding wheel, as at present. The reversing of the car was obtained by disengaging one loose bevel wheel and engaging with another, both of which were in gear with the pinion on the change-speed shaft. The power transmission was by means of a chain from the transverse shaft to the centre of the rear axle. The front wheels were steered on the same principle as at present, and were controlled by a lever placed at the left hand of the driver. There was a lever for the change-speed gear, and there was a clutch pedal which was coupled with the brake lever; this prevented the brake being applied while the engine was driving the car. The one member of the clutch was in two parts, separated by springs,

and its inner surface was at an acute angle, so that its first contact with the other cone allowed a certain amount of slip and thus prevented too sudden an engagement.

The wheels were of wood with solid rubber tyres, though iron tyres were still in use at that time.

Another engineering firm (Peugeot) had taken

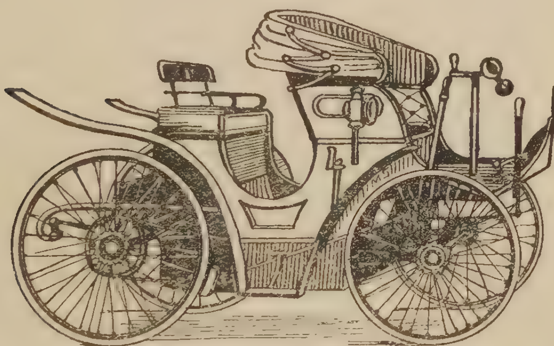

FIG. 16.—AN EARLY PEUGEOT.
This car had a Daimler engine at the rear and was tiller steered.

up the manufacture of motor-cars in France in 1890, and of the three hundred and fifty engines made by Daimler up to 1894, this firm had bought eighty. This firm had been manufacturers of bicycles, and their cars followed on the same lines; the Peugeot cars had the engines at the rear. Another car manufacturer (Mr. Roger, of Paris) took over the Benz motor and converted it from a two-stroke to a four-stroke engine. The gear had two speeds (3 and 12 miles per hour),

and these were got by means of a counter shaft with belt pulleys. Arrangements were made for varying the explosive mixture, so that intermediate speeds could be obtained. The power transmission was by chains from the centre shaft to the rear axle, and the steering was as at present, but the steering wheel had not yet appeared. By the end of 1897 there were no less than fifty of these cars on the Continent.

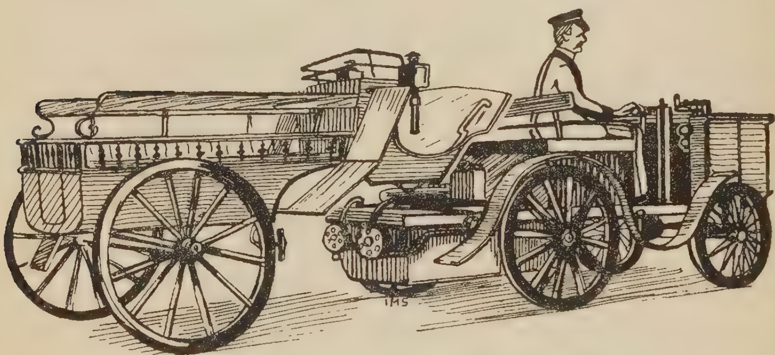

FIG. 17.—DE DION BOUTON STEAM TRACTOR.

So early as 1883 the Comte de Dion and his partners Bouton and Trepardoux had given their attention to motor-cars. This was before the arrival of the Daimler motor, so they confined themselves to steam carriages. With a 1 horse-power engine they are said to have attained a speed of 18½ miles per hour, this was with a tandem tricycle.

The most curious of these cars was a tractor (Fig. 17). This tractor took part in the Paris-

Rouen Competition, 1894, and in the Marseilles-Nice race in 1897 one of De Dion Bouton steam carriages came in an easy first.

For our present purpose we may pass over the steam carriages of Scotte and Le Blant, and this brings us to the commencement of petrol motor-cars in Great Britain.

THE ADVENT OF THE PETROL CAR IN GREAT BRITAIN

The apathy of this country was no doubt due to the prohibitive Act of Parliament, and some may be surprised that a commencement was made in 1895, before the repeal of the Red Flag and 4 miles per hour Act. The people using motor-cars did so in contravention of the law, as will be seen in the succeeding chapter.

Then Mr. Evelyn Ellis brought over to this country a Panhard and Levassor car of 4 horse-power, and a little later Sir David Salomons brought over a Peugeot car.

A demonstration of those cars, plus a De Dion Bouton steam tractor and a petrol tricycle, was given at Tunbridge Wells. Engineers and others flocked there from all parts of the country, and the meeting was quite a success.

Further interest was stimulated by Sir David Salomons reading papers upon the subject before scientific societies and by writing articles for newspapers. Later, an International Horseless Carriage Exhibition was held at the Imperial

Institute, and shortly afterwards a show was held at the Crystal Palace.

It was in 1895 that Mr. J. H. Knight of Farnham, Surrey, built the first petrol motor-car made in Great Britain. It was a three-wheeler, and carried two passengers, and was of 1 horse-power. It had only run 150 miles when ordered to stop by the Surrey County Council.

Then came the Act of 1896, as quoted in the succeeding chapter.

In the United States of America, where there were no such restrictions as in Great Britain, things were further advanced. By the end of 1895 there were three hundred cars in the course of construction. Henry Ford had built his first "gasolene buggy" in the spring of 1893. It had a two-cylinder engine, and one is surprised that it was able to go at a speed of 20 miles per hour. This was better than had been done on the Continent, as will be seen later in Chapter VII, where we will find that the best the French could do, even in 1895, was 15 miles per hour.

Ford still possesses his first car, which he declares is as good as the day it was built.

In passing, it is interesting to note how Ford was led into the automobile business. His father wished him to follow in his footsteps as a farmer, but young Ford was keenly interested in mechanics in his boyhood. He tells how, when he was twelve years of age, he happened to see an engine travelling on the road, making its way from farm to farm to thrash corn. He was not

content until he learned from the engineer how the road engine worked. Ford tells how this meeting with the road engine was the biggest event in his life. This incident occurred in 1875, and, referring to it, Ford says : "It was the first horseless vehicle I had ever seen. It was that engine took me into automotive transportation."

He tried to make models of the road engine, and some years later succeeded in making one which ran very well. From the time he saw that road engine his ambition was to make a machine that would travel on the roads.

In 1898 there was one car to every 18,000 people in America. Twenty-five years later (1923) there was one car to every eight people. In that year it was estimated there were no less than thirteen million cars in America, consuming six billion gallons of petrol per annum.

CHAPTER V

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CHAPTER V

THE ACTS OF PARLIAMENT

THE two Acts of Parliament relating to mechanical vehicles, which are of special interest in connection with the evolution of the motor-car, are those of 1865 and 1896, the former being responsible for the long delay in the advent of the motor-car.

Many writers refer to "the 1836 Act" as having killed the early steam carriages, but I can find no such Act. There was a Bill which never became law, and which was possibly thrown out because of the following Committee report (published in 1836):

"The Committee entertain serious objections to the Bill referred to them, and they are not of opinion that these opinions are counter-balanced by the Prospect of any great Public Advantage."

The Bill was to "repeal such portions of all Acts as propose prohibitory tolls on steam carriages, and to substitute other tolls on an equitable footing with horse carriages."

In evidence before the Committee Mr. Gurney

mentioned some of the tolls, which were as follows :

On the Liverpool and Prescot road his steam carriage would have to pay £2 8s., while a horse-drawn carriage only paid four shillings.

On the Ashburnham and Totnes road his steam carriage paid £2 against three shillings for a coach drawn by four horses.

There seems little doubt that these high tolls assisted in killing the steam carriages, but there was also much opposition shown by people placing obstacles on the roads to hinder the use of steam carriages.

It may be of interest to consider some extracts from the Acts relative to speed. I quote from the 1861 Act in order to give the Acts of 1865 and 1896 their proper setting.

1861 Act.—"It shall not be lawful to drive any Locomotive at a greater Speed than Ten Miles an Hour, or through any City, Town, or Village, at a greater Speed than Five Miles an Hour, and any person acting contrary thereto shall for any such offence, on summary Conviction thereof before two Justices, if he be not the owner of such locomotive, forfeit any sum not exceeding Five Pounds, and if he be the owner, shall forfeit any sum not exceeding Ten Pounds."

Permission to travel at 10 miles per hour in the open country was withdrawn by the Act of 1865, from which the following is an extract :

1865 Act.—"Subject and without Prejudice to the Regulations hereinafter authorised to be made

by Local Authorities, it shall not be lawful to drive any such Locomotive along any Turnpike Road, or public Highway, at a greater Speed than Four Miles an Hour, or through any City, Town or Village, at a greater Speed than Two Miles an Hour; and any person acting contrary thereto shall for every such offence, in Summary Conviction thereof, forfeit any sum not exceeding Ten Pounds."

Then the Act goes on to say:

"Firstly, at least three persons shall be employed to drive or conduct such Locomotive. . . . Secondly, one of such persons, while any Locomotive is in motion, shall precede such Locomotive on foot by not less than Sixty Yards, and shall carry a Red Flag constantly displayed, and shall warn the Riders and Drivers of Horses of the approach of such Locomotives, and shall signal the driver thereof when it shall be necessary to stop, and shall assist Horses, and Carriages drawn by Horses passing the same. . . ."

This 1865 Act was still in force when motor-cars were introduced into Great Britain, and those using motor-cars did so in contravention of the law.

Mr. Elliott of Kelso, who was the first to bring a motor-car into Scotland, was fined sixpence for travelling at a greater speed than 4 miles per hour, and for failing to have a man with a red flag preceding his car. I am told that the first car entering Glasgow was stopped for the same reason.

At the time when Sir David Salomons had succeeded in arousing public interest in motor-cars in Great Britain it was evident that no real progress could be made so long as the 1865 Act, with its speed limit of 4 miles per hour, remained the law of the country.

In 1895 a Bill to amend the law was prepared but was postponed owing to a change of Government. It was brought forward again on 4th August, 1896, and became law on 14th November, 1896. On this occasion the motorists made a procession with twenty cars from London to Brighton.

The following is quoted from the 1896 Act which repealed the deterrent Act of 1865 :

1896 Act.—" No light locomotive shall travel along a public highway at a greater speed than 14 miles an hour. . . ."

Then came the Act of 1903, which motorists feel requires amendment both as regards the speed permissible in the open country as well as the speed limit in villages.

1903 Act.—" Section 4 of the Principal Act [1896] (which relates to the speed of motor-cars) is hereby repealed, but a person shall not under any circumstances drive a motor-car on a public highway at a speed exceeding twenty miles per hour, and within any limits or place referred to in regulations made by the Local Government Board with a view to the safety of the public, on the application of the Local Authorities of the area in which the limits or place are situate, a

person shall not drive a motor-car at a speed exceeding ten miles per hour."

Lord Montagu of Beaulieu says of the 1903 Act:

"The discussion of the Bill began on Friday at twelve noon, and lasted throughout that day and the following night until four o'clock the next morning, when only a handful of members remained in the house. We were able to get from time to time many concessions, which have since proved valuable, concessions obtained not so much by the force of our arguments as by the sheer weariness of those who were opposing us."

And again:

"When the Motor Act of 1903 was first laid on the table of the House of Lords it seemed as though everything would be unexpectedly smooth except for matters of detail, as there was originally no speed limit proposed by Government, and, moreover, the House of Lords in discussing the Bill agreed that there should be none, though the powers to deal with inconsiderate and reckless drivers was strengthened. I still believe that this was the soundest and sanest view, and if it had been adopted it would have obviated much subsequent friction and difficulty."

CHAPTER VI

CHAPTER VI

THE EVOLUTION OF THE MOTOR ENGINE

THE internal combustion engine may be said to be a direct decendant of Huyghen's gun-powder engine (1680), in the same sense as James Watt's steam engine is descended from Newcomen's atmospheric engine.

It is surprising to find an internal combustion engine as early as 1838, which comes within the steam carriage period of 1824–40. In 1838 Wm. Barnett invented a double-acting gas engine. It had a single cylinder, which was placed in a vertical position, and an explosion took place on either side of the piston head alternately. On the instroke the cylinder accepted a compressed mixture of gas and air. This was compressed further by the piston, and at the end of its stroke the gas was ignited and the explosion drove the piston downwards. The next explosion took place on the other side of the piston head and drove it upwards.

The means of ignition in Barnett's engine is of interest. It was obtained by means of a gas jet within a closed and hollow taper plug, which fitted into a conical sleeve and was held in a gland. The sleeve had two slotted ports cut in

it, and when it revolved it closed one port and opened the other. The gas flame ignited the gas mixture when the plug port and the shell port were opposite to one another. When the explosion occurred it extinguished the flame of the gas jet, but this was relighted at the required moment by means of an external gas jet.

Barnett's gas engine was very wasteful of gas and did not prove of practical service, but it is of interest to us as an ancestor of the motor-car engine. No progress in gas engines was made for the best part of a generation. The next forward step was due to the Frenchman, Mons Lenoir, and was made in 1860. There was nothing really new in his methods, but it was a more practical machine than Barnett's engine.

Lenoir made several hundred gas engines, the largest being about 3 horse-power. One advantage in his machine was that it started up easily after admitting the gas; only a few revolutions of the flywheel being necessary to set the engine going. It was very silent also. It is interesting to note that Lenoir used an electric battery and induction coil to produce a spark and thus ignite the gas mixture.

One of Lenoir's gas engines propelled a carriage on the streets of Paris in 1862.

We may pass over the work of another French mechanic (C. Hugon), whose engine used the gas jet ignition. This engine, although patented in 1858, did not appear until that of Lenoir (1862).

About this time another continental engineer

formed entirely new theories of the gas engine, and these led to great improvements some time later. One thing resulting from these theories was the higher speed engine, which does not give the gas mixture so much time to cool before ignition takes place.

In 1866 Otto and Langen (Germany) invented the then well-known gas engine to which I have referred already. Originally it had a straight rack worked to and fro by the piston-rod, and this rack engaged with a spur pinion, thus giving the rotary motion to keep the flywheel revolving. The great advantage in this engine was that the consumption of gas was one half of the then existing engines. It was much in use for ten years, until the same inventors introduced an entirely new motor, on the compression principle already attempted by Barnett. Otto thought that in his engine the gas mixture was in layers of gas and air alternately, but this was an entirely erroneous idea.

The first really satisfactory electric ignition apparatus seems to have been made in 1884 by two Frenchmen, Deboutville and Malindin. The spark was obtained from a battery and induction coil. These two men invented a gas engine, but it was so much akin to the Otto and Langen engine that legal proceedings were taken against them.

The next step in the evolution was made in 1885 by Daimler, who, as already stated, had worked with Otto and Langen. Daimler's motor

was so light that it was suitable for propelling carriages. I have already given a general description of the motor, and, as already stated, Carl Benz followed Daimler with a benzine motor, and others followed. The four-stroke engine still holds the field to-day.

The multiplicity of cylinders and improved carburettors were easy stages in the evolution, and the step from a battery and an induction coil to the mechanical magneto was natural. One does not often see the battery and induction coil in existence now, but a few years ago I came across one on the following occasion.

I was motoring from Abington to Glasgow and was passing across a moor about 9.30 p.m.; it was Saturday. It was a miserable night of drifting rain, and all cars were closed. About the centre of the moor I was hailed by a gentleman from a standing motor, who requested me to send a mechanic out from Lanark. I explained that we did not pass through Lanark, and that he should have taken the other leg of the Y at Abington. The best we could do would be to try and get someone at Lesmahgow, but I feared that it would be very difficult to induce a mechanic to turn out, and I doubted if a mechanic could be found there on a Saturday night. I offered to assist him, but he said that it was no good as his battery had run out and his car ignition was from the battery and induction coil.

I suggested that we might have a look at the

accumulator, but he thought it hopeless. However, as he had his wife, three children, and a nurse in the car, and as it was very uncomfortable on the open moor on such a night, he allowed me to examine the battery. The first two cells were very much heated while the remaining cells were cool, so I suggested that the two cells, with an evident short circuit, should be cut out and the others coupled up. The motorist was unwilling to bother with this as he had no faith in the cure. I insisted, and, after the new connections were made, suggested the starting up of the engine. He made a very half-hearted attempt, and was about to give it up when I maintained that it would go with a more vigorous cranking. A second attempt put the engine in motion, at which the motorist was very much surprised and also very grateful. I mention the incident so that we may appreciate the great advantage of a magneto, despite its very occasional trick of going on strike.

We have seen the evolution of the motor engine, and before passing on it may be of interest to see how some of the other parts came about.

The differential gearing may be traced back to 1833, when it was applied to a steam carriage by Richard Roberts of Manchester. This did away with the necessity of having one of the rear wheels loose upon the shaft to enable one wheel to travel faster than the other and thus prevent skidding in turning a corner. The

principle of the differential gear was known as early as 1822, and a planetary gear was used in 1828 in Recquer's steam waggon in France.

We have seen that the water jacket was used in one of the early gas engines ; the water-cooling may be worked by gravity, the hot water rising above the cold water, or a centrifugal pump may be added.

All motorists know that the petrol supply may be fed by gravity, in which case the tank must be above the engine, or, on the other hand, the tank may be placed behind the car, in which case the petrol must be forced forward by atmospheric pressure, when a vacuum is produced by the engine, and in which case an autovac is used. Details of these float chambers are given in motoring books.

Rubber tyres were first introduced on horse carriages, and the commencement was made by placing the india-rubber between the iron rim and the wooden felloe. In 1867 a steam carriage was fitted with solid rubber tyres on the outside of the wheel, and there was much demand for this new comfort. At one time the cost was as much as £240 for a set of rubber tyres.

Robert Miller Thomson invented an india-rubber tyre in 1845, and there is no doubt it was pneumatic. I quote the following from the specification, No. 10990, 10th December, 1845 :

" The nature of my said invention consists in the application of elastic bearings round the tyres of the wheels of the carriage for the purpose

of lessening the power required to draw the carriages rendering their motion easier and diminishing the noise which they make when in motion. I prefer employing for the purpose a hollow belt composed of some air- and water-tight material, such as caoutchouc or gutta-percha, and inflating it with air, whereby the wheels in every part of their revolution present a cushion of air to the ground, or rail, or track."

The reason for nothing practical resulting from the patent was doubtless the high cost of india-rubber at that time; it had not got far beyond the rubbing out of pencil marks, which property was discovered in 1770, and also as flexible tubes for surgeons and chemists. The price was about three shillings per cubic half inch.

It will be of interest to note how one or two of the early cars came to be made. It is not surprising that a cycle manufacturer should turn his attention to motor-cycles and then to motor-cars, nor that a manufacturer of internal combustion engines should seek to apply these to locomotion, but it is surprising to find a manufacturer of printing machinery entering the field as a manufacturer of motor-cars, and at a time before any demand was created. That is what happened in the case of the Napier Company, who had carried on, for one hundred years, the manufacture of special machinery for printing bank-notes, and had also made those wonderful weighing machines which detect very small differences, and which separate light from full-

weight sovereigns, etc. The Napier car entered the field in 1899, and the industry being a new one, there were many difficulties to overcome.

Before this date the Lanchester car had been made (1896), it being the first British-made car driven by a petrol engine. It is interesting to note that this pioneer car had such up-to-date things as wire wheels, live axle, worm drive, direct drive on top speed, epicycle change-speed gears, mechanically operated valves, and mechanical lubrication. It used ordinary benzole as petrol was difficult to obtain at that time. The average speed of the car was 12 miles per hour.

Mr. F. W. Lanchester was associated with the design and construction of the "Forward" gas engine, and in 1893 he had designed a single-cylinder vertical engine for electric lighting. One of these engines was modified later for using petrol fuel in place of gas.

The entrance of the Daimler Company into the motor industry has been referred to already, and it seemed natural that Gottlieb Daimler (1834–1900) should enter the industry because of his connection with the Otto Gas Engine Works in Germany. It will be remembered that he applied his engine to a bicycle and then to a tricycle in 1887.

The Panhard cars, which did so well in all the early races, were made under a licence from the Daimler Company.

An interesting story of the advent of the Rolls-Royce car was told by Mr. Henry Edmunds in

some reminiscences in Mavor and Coulson's *Apprentice Magazine* (1922). It was Mr. Edmunds who introduced Rolls to Royce.

The Hon. C. S. Rolls was the third son of Lord Llangattock, and was one of the most active of pioneers of modern locomotion. He began as a cyclist, and when motoring was introduced he took part in many contests in different parts of Europe; he was the victor in the Thousand Miles Trial (1900).

One day he said to Mr. Edmunds, "I wish you would give me any information you may get hold of relating to improvements in the building of motor-cars. I have some ideas of my own which I should like to follow out, and there may be opportunities of doing so."

It so happened that Mr. F. H. Royce had been building a motor-car according to his own ideas, which he wished Mr. Edmunds to see. This was in the spring of 1904. He told Mr. Rolls about this car, and he said he would like to have an opportunity of meeting Mr. Royce and trying the car himself.

Mr. Edmunds told Mr. Royce that Mr. Rolls was anxious to see his car, and an introduction followed. Mr. Edmunds relates a conversation he had with Mr. Rolls on their journey to see Mr. Royce.

"I well remember the conversation I had in the dining-car of the train with Mr. Rolls, who said it was his ambition to have a motor-car connected with his name so that in the future it

might be a household word, just as much as 'Broadwood' or 'Steinway' in connection with pianos, or 'Chubbs' in connection with safes. . . . I remember we went to the Great Central Hotel and lunched together. I think both men took to each other at first sight and they eagerly discussed the prospects and requirements of the automobile industry, which was still in its early infancy. Mr. Rolls then went to see for himself the Royce car, and the result was the founding of the famous Rolls-Royce firm, of which Mr. Edmunds was spoken of as the godfather.

It will be remembered that Mr. Rolls was killed in an aeroplane crash in 1910 at the age of thirty-three years.

CHAPTER VII

CHAPTER VII

SOME EARLY RACES

THERE is no doubt that races and trials helped in the evolution of the motor-car; we still believe in the utility of these.

The Paris–Rouen contest of 1894 has been mentioned already, but it may be of interest to consider it in greater detail. It was organised by the French newspaper *Le Petit Journal* as a "competition for carriages to be propelled without horses." The date of the trial was 22nd July, 1894. More than one hundred cars entered, and these may be classified as under:

38 petrol cars.
29 steam carriages.
5 electric carriages.
5 compressed air carriages.
25 others failed to take part.
102 cars in all.

It would be of interest to know the details of some of those which did not run, as one of them was said to be driven by the weight of its passengers, which only sounds practicable provided the course was downhill.

There was a preliminary trial run of 30 miles,

failed to find any notice taken of it in the London *Times*, or the *Glasgow Herald*, or the English illustrated papers. There appears to have been no interest at that time, and yet the *Autocar* magazine appeared the following year (1895).

The next great contest was from Paris to Bordeaux and back to Paris. This was in 1895, and the distance covered was 732 miles. This trial was initiated by the Comte de Dion, who played an important part in the evolution of the motor-car, as mentioned in Chapter VI. On this occasion it was decided that the trial should be a race, the prize to be for speed alone; the consumption of petrol was left out of account. It is interesting to note that although the distance to be covered was over 700 miles an electrically driven car was entered as a competitor. There were forty-six entries in all, but only twenty-two cars turned up for the race. These may be classified as under:

11 petrol motor-cars.
6 steam carriages
4 petrol motor velocipedes.
1 electrically driven car.
22 in all.

About one half of these failed to reach Bordeaux, twelve cars reaching that point within the time limit, and of these twelve, one was disqualified. Only nine completed the double journey, and these were all petrol cars with the exception of one steam carriage. A Panhard

car came in first. The time taken to cover the double journey of 732 miles was $48\frac{3}{4}$ hours, giving an average speed of 15 miles per hour, which was a small advance on the speed of the 1894 contest, in which, however, speed was not taken into account.

The Panhard and Levassor car was driven by Mr. Levassor himself, who drove the whole way, with one stop of eight minutes at Bordeaux. A series of relay drivers were arranged for the other cars. It was a remarkable achievement for Mr. Levassor to drive for two days and two nights with only a rest of eight minutes. It also spoke well for the reliability and ease of control of the car.

Although the Panhard car came in first it did not gain the first prize, which was for a vehicle carrying four persons, whereas the Panhard only carried two passengers. For this reason the Peugeot car, which came in second, won the first prize; the Panhard was given the second prize. One of the competing cars carried eight passengers, and the reason for so many seems to have been to provide plenty of repairers in the case of a breakdown, which had to be done by the passengers alone. This car might be described as a steam omnibus; it weighed about 5 tons. It required to have its water tank refilled at the end of every 25 miles, and its fuel only lasted 90 miles, so that it would require to stop for fuel at least seven times on the journey and about thirty times for water.

One of the competing cars ran over a dog, came down with a jerk, and broke a rear wheel. It is evident that no spare wheels were carried in these days; the passengers were helpless and had to abandon the race.

At a banquet given after the 1895 contest one of the speakers was bold enough to prophesy that at some future date the speed would rise to 50 miles in place of 15 miles per hour, whereupon Mr. Panhard whispered to the chairman that it was unfortunate that there was always one person who made an ass of himself; the prophecy of 50 miles per hour came true within six years.

In September, 1886, a race was held over a greater distance, 1061 miles, from Paris to Marseilles and back to Paris. On this occasion there was not much advance in speed, the average time of the winner being 15½ miles per hour. In 1897 the speed of motor-cycles in a race from Marseilles to Nice were:

Winning car .	7 hr. 45 min. 9 sec.
Winning cycle .	9 hr. 23 min. 36 sec.

The following is quoted from the *Automotor* of February, 1897: "Mishaps were fairly plentiful, mainly happening to the motor-cycle, which somehow seemed to be in the way."

The same journal in describing this race says:

"The inhabitants of the various villages and towns turned out in full force and gave the automotorists a very cordial welcome as they passed. Several accidents happened towards the end of

the first day's run, obstructions on the road being the chief cause of the upsets which occurred . . . were bothered a great deal with punctures."

The list on page 109 has been compiled to show the progress in horse-power and speed.

It will be of interest to enquire what was happening in Great Britain during the above period. Trials of efficiency were made in place of tests of speed; there were no road races of any description, but tests of speed were made on a private road in Welbeck Park.

The tests made were hill-climbing, petrol consumption, brake trials, and a non-stop run of 100 miles. In the hill-climbing in 1899 at Petersham Hill the maximum gradient was 1 in 9·43, and this was climbed at an average speed of 5 miles per hour, but the Hon. C. S. Rolls climbed at the rate of $8\frac{3}{4}$ miles per hour on an 8 horse-power Panhard.

In 1900 there was the Thousand Mile Trial, for which sixty-five cars entered, and almost all of them completed the distance, and "attained speeds not less than the legal limit," which was then 14 miles per hour. This trial was arranged by the Automobile Club, and took place from April 23rd to May 12th, 1900. The club did not record any speed higher than the legal limit. The Hon. C. S. Rolls was the winner.

There was a speed test in Welbeck Park, and in this Rolls averaged 37·63 miles per hour in a 12 horse-power Panhard.

In 1902 an interesting trial of brake-power was

Date.	Course.	Distance.	Winning Car.	Average speed.
1894	Paris-Rouen	78 miles	3½ h.p. Panhard 3½ h.p. Peugeot	12 m.p.h.
*1895	Paris-Bordeaux-Paris	732 ,,	3½ h.p. Panhard	15 ,,
1896	Paris-Marseilles-Paris	1061 ,,	4 h.p. ,,	15½ ,,
1897	Paris-Dieppe	106 ,,	6 h.p. ,,	23 ,,
1898	Paris-Amsterdam	895 ,,	8 h.p. ,,	29 ,,
1899	Paris-Bordeaux	330 ,,	12 h.p. ,,	33½ ,,
1899	*Jour de France*	1440 ,,	16 h.p. ,,	32 ,,
1900	Circuit du Sud-Oust	208 ,,	16 h.p. ,,	43½ ,,
1900	Bordeaux-Perigeux-Bordeaux	195 ,,	Mors.	48 ,,
1900	Paris-Lyons	347 ,,	Panhard	38 ,,
	(This was the first Gordon Bennett Race.)			
1901	From Pau	205 miles	24 h.p. Panhard	46 ,,
1901	Paris-Bordeaux	327 ,,	60 h.p. ,,	53 ,,
	(This was the second Gordon Bennett Race.)			
1901	Paris-Berlin	749 miles	60 h.p. Mors	46½ ,,
1902	Paris-Vienna	615 ,,	70 h.p. Panhard	38½ ,,
1902	Circuit des Ardennes	318 ,,	70 h.p. ,,	54½ ,,

* (As explained in the text, the Panhard was disqualified and the second car, a Peugeot, was awarded the prize. Speeds have now risen to 170 miles per hour.)

made at Welbeck Park, and the results are given below. This note gives the distance within which the cars could be brought to a standstill :

Speed	11 to 14	miles	per hour	$1\frac{5}{8}$	times the	car's length.
,,	15 to 17	,,	,,	2	,,	,,
,,	18 to 20	,,	,,	$2\frac{3}{4}$	,,	,,
,,	20 to 24	,,	,,	$3\frac{1}{2}$	,,	,,

CHAPTER VIII

CHAPTER VIII

THE EVOLUTION OF THE ROADS

ROADS have played an important part in the evolution of the motor-car, and conversely the motor-car has played an important part in the evolution of the roads.

Samuel Smiles has said, "Roads are literally not only the pathways of industry, but of social and national intercourse," and the stated opinion of Lord Montagu of Beaulieu is, "There is nothing of greater influence on humanity than the roads."

Think of Richard Trevithick requiring to dig large rocks out of the roads and to cut down trees before his car could pass; this was during the opening years of the nineteenth century. When we read some of the descriptions of the early roads we are amused, and we are not surprised that canals and railways superseded the roads, and now it looks in some measure as though the roads are going to supersede the railways, while the canals are no longer of primary importance.

It is well known that the Romans made good roads in Great Britain. *Watling Street* represents the Roman road from Kent to Chester and York, while *Ermin Street* led direct from London to Lincoln, with a branch road from Doncaster to

York. The Roman roads gradually fell into decay and were allowed to get into a shocking condition.

In Henry VIII's time when old roads were found too deep and muddy to be passed they were ignored and new tracks were made. The Great Western Road, in London, was especially bad, and about Knightsbridge, in winter, the travellers had to wade through deep mud. At a greater distance from London the roads were still worse; they were described as "furrowed with deep ruts as ploughed fields, and in winter time to pass along one of them was like travelling in a ditch."

Sussex roads were so bad that when there was a really bad bit in any road it was described as "the Sussex bit of the road." One of the writers of these early times suggested that the reason why the Sussex girls were so long limbed was because of the tenacity of the mud in that country, the practice of pulling the foot out of it "by the strength of the ancle" tending to strengthen the muscles and lengthen the bones.

In the seventeenth century it sometimes took two days to travel 22 miles to London.

In 1736 Lord Hervey wrote from Kensington:

"The road between this place and London is grown so infamously bad that we live here in the same solitude as we would do if cast on a rock in the middle of the ocean; and all London tells us that there is between them and us an impassable gulf of mud."

In travelling from St. James's Palace to Kensington Queen Caroline's carriage often stuck fast in the ruts, and on one occasion her carriage was upset.

The roads were so bad that there was no pleasure in travelling by carriage; the poor walked and the rich rode on horseback. Ladies rode on pillions, which were much safer than present-day pillion seats.

One writer of the seventeenth century tells how on one occasion while journeying to London rain fell which "raised the washes upon the road to that height that passengers from London that were upon that road swam, and a poor higgler was drowned, which prevented me travelling for many hours; yet towards evening we adventured with some country people, who conducted us over the meadows, whereby we missed the deepest of the wash at Cheshunt, though we rode to the saddle skirts for a considerable way."

(The word higgler means one who higgles, and to higgle is to hawk or carry goods about.)

On another occasion the same writer tells us he was detained four days at Stamford by the state of the roads. During the Civil War 800 horses were captured through sticking in the mud.

Sometimes the carriages were taken to pieces and carried over bad bits on the shoulders of strong peasants.

Samuel Smiles says that stage-coaches were at first opposed and for the following reasons:

"Those who were accustomed to travel in coaches became weary and listless when they rode a few miles, and were unwilling to get on horseback." And again: "They were not able to endure frost, snow, or rain, or to lodge in the fields." It was to "save their clothes and keep themselves clean and dry that people rode in coaches, and thus contracted an idle habit of body; that this was ruinous to trade, for that most gentlemen, before they travelled in coaches, used to ride with swords, belts, pistols, holsters, portmanteaux, and hat cases, which in these coaches they had little use or no use for; for when they rode on horseback they rode in one suit and carried another to wear when they came to their journey's end, or lay by the way; but in coaches a silk hat and an Indian gown with a sash, silk stockings and a beaver hat, men ride in, and carry no other with them, because they escape the wet and dirt which on horseback they cannot avoid."

Another writer says: "Is it for a man's pleasure to be laid fast in the foul ways and forced to wade up to his knees in mire; afterwards sit in the cold till teams of horses can be sent to pull the coach out?"

Tolls to repair the roads were made as early as 1346 by King Edward III; some of the roads of his time now form the streets of London.

One does not wonder that the word travel is

derived from the word *travail*, which means hardships and labour.

In the beginning of the eighteenth century, when the Duke of Somerset was about to travel from his London house to his estate in the country, he wrote a letter requesting that persons who knew the holes and sloughs in the road should come to meet him with lanterns and long poles. The roads were so bad at this time that twenty and sometimes thirty horses were required to draw a waggon out of the ruts.

In 1770 there were ruts in the road from Wigan to Preston as deep as 4 feet; these were actually measured; they were full of mud. We cannot imagine anyone going for a pleasure drive in these days.

Cases of bad roads could be quoted indefinitely, but what interests us now is not so much the gradual improvement but the big step forward made by John Loudon Macadam.

Macadam left Great Britain in 1770 to enter his uncle's business in New York, and by 1783 he had become a successful merchant and returned to this country, where he bought an estate in Ayrshire.

He began experiments in the construction of roads in 1810, and he became fascinated with the subject, spending £5000 on experiments and travelling 30,000 miles in gaining experience.

In 1816 he was appointed surveyor to the Bristol Turnpike Trust, and he remade their roads both cheaply and well.

His method is well known; instead of using round stones he used broken "metal," making a top layer of 6 or 10 inches deep, each stone being from 1 to 2 ounces in weight.

His method was recognised to be of so much importance that the House of Commons in 1819 elected a select Committee to consider it.

Like many another inventor he did not make a fortune; indeed, he lost his all, and petitioned Parliament for a repayment of his expenses plus a reward. At first this did not meet with success.

Three years later he petitioned Parliament a second time, with the result that he was awarded the sum of £10,000. He declined a knighthood.

Motorists have seen great improvements in Macadamised and other roads, but some people have imagined that Scotland does not get such good roads as England. When Lord Montague of Beaulieu read a paper on Roads before the Royal Philosophical Society of Glasgow one member asked why Scottish roads were inferior to English roads, and one of the chief surveyors replied that the English possessed something that they could not pass on to Scotland, namely, a better climate, especially a lower rainfall.

CHAPTER IX

CHAPTER IX

MODERN METHODS OF MAKING MOTOR-CARS

THE alliteration in the heading of this chapter was quite accidental, not being seen until it was written. The subject is of sufficient interest to be included in this history, for it is interesting to see how things can be done quickly and without undue haste. When it is stated that the body of a car receives one complete coat of paint in less than two minutes, and that forty-eight holes are drilled in the chassis in twenty seconds, it may seem like magic, and yet that is what takes place in a modern factory.

The works of the Morris Motors Ltd., Cowley, Oxford, were selected as they turn out 1100 cars per week, or 200 per day, and through the courtesy of the firm I paid a visit to their works in order to write a non-technical description.

When Richard Trevithick built his first steam coach he had the different parts made in different places, and then all the parts were put together in John Tyack's blacksmith's shop; the same plan is adopted to-day, the works of Cowley being the point at which all the different parts are assembled, and from which the complete car is

delivered; the engine and machinery for the car arrive from other factories belonging to this firm.

The Cowley works have a suction gas plant as source of energy, and they distribute the power to individual motors throughout the work, there being, of course, intermediate dynamos.

As this book deals with the science as well as the history it is worth while making sure that there is no mystery as to the part played by the dynamos and motors.

As already stated, it was Gramme who discovered that a dynamo might be used as a motor. We supply mechanical energy to the dynamo by revolving its armature, and we get a supply of electric current. We supply the electric motor with a current of electricity and we get mechanical energy from the revolving armature. In one case we revolve the armature and lead out an electric current; in the other case we lead in an electric current and cause the armature to revolve.

It was Michael Faraday who discovered in 1831 that when a coil was moved in a magnetic field there was an electric current produced in the moving coil, but it took forty years to evolve a practical self-acting dynamo.

It is evident that an electric motor is not a prime mover; it is the suction gas plant which drives the machinery through the dynamo and motor, the electric current acting as a go-between.

I need scarcely say that all the different parts which go to make the motor-car are not dumped

down in one place for one group of men to deal with; the parts are added little by little as they pass from one group of workmen to another, till they all meet at a main erecting track, at the exit of which the complete chassis appears, the body being added in another workshop.

We will consider the tributary tracks first of all and see each ready to deliver its part to the main track.

At the beginning of one track we see the bare propeller shaft, more commonly called by motorists the transmission shaft, as it transmits the power from the engine to the driving wheels.

The propeller shafts are supported in a vertical position on a sliding track while the bevel wheels are added. The track, along which the shafts are pushed from one group of workmen to another, is about 4 feet from the ground, and the free end of the shaft hangs downwards. When the bevel wheels are completed the shafts are lifted by a compressed-air crane and moved on to a turn-table, which reminds one of a merry-go-round. Here the back axle is added.

On leaving the turn-table the propeller shaft with its addition is moved on to another elevated track along which it is pushed from one group of workmen to another, and it moves along this, lying at an angle, in a more horizontal position. In its journey it receives the cover of the bevel wheels, then the oil nipples, the rear springs, the brake shoes, the brake drums, and a pair of temporary wheels. Why not give it its own

wheels right away? Because when the chassis comes to be painted later the wheels would catch some of the sprayed paint.

It is convenient to add the wheels at this point as the shaft with all its appendages has become fairly heavy; now the whole affair may be moved, running on the temporary wheels, which of course do not get tyres. This part of the car is now ready for linking up with the main track, and we must leave it here till required and until we have seen another tributary track.

As already stated, the engines arrive at the works from another factory; they come each on a small four-wheeled trolley. We see a large rack containing 2500 engines, which is equivalent to about two weeks' supply. There are a great many different tracks in many flats or storeys, on to which the trolleys are lifted by means of a travelling lift. The trolleys with their engines are pushed along this rack by one man who takes care of the whole lot. When they reach the far end of the track they are pushed one by one on to another travelling lift, which carries them to an elevated track, on which they are to have additions made. The reason for having this track so high up is to take advantage of gravitation to pull the empty trolleys back to the carting entrance. When the engine arrives at the end of the track a crane lifts it and lowers it down to a waiting chassis frame on the main assembly track while the empty trolley runs home.

Before seeing the engine added to the chassis we must see how the chassis enters the main track. As already stated, there are forty-eight holes to be drilled in the chassis frame, and as these are made in 20 seconds it is apparent that they must all be made simultaneously. Twenty seconds is the actual time required to drill the holes, and the total time required to place the frame in position, clamp it down, drill the holes and lift it out of the drilling machine is 90 seconds. The chassis frame is placed in the centre of a flat machine, on which a clamp holds it in position. Then the forty-eight drills are brought into position and revolved by the means of an electric motor, there being one to each side of the machine. While the drills are in action they are kept cool by a flow of soapy water. When taken from this drilling machine, the frame is placed on a track along which it is pushed with ease.

The first additions to the frame are the brackets for carrying the running boards, and also the shock absorbers. Then the front axle is placed in position and a pair of temporary wheels added. It is at this point that the propeller shaft, with its pair of temporary wheels, joins in with the main track on which the chassis frame is being built. From this point onwards the chassis runs on the temporary wheels, being guided by a wooden track. While the rear wheels, etc., are being added the engine also joins the main track, but before seeing the engine placed in the chassis it

will be of interest to see what happens to the engine after being placed on its tributary track.

The first thing to be added to the engine is the motor dynamo, which operates the starting and the lighting, etc. Then the carburettor is fixed in position, the brake pedals are adjusted, and the magneto added. A gauge is used to indicate the position of the first cylinder's piston, so that the magneto may be timed properly. After this the fan and the casing for the universal joint are added, and the engine is ready for lowering into the waiting chassis. The fitting in of the propeller shaft and rear wheels and the fixing in of the engine is done by six men in 65 seconds, and there is no undue haste.

Then the steering wheel is added, while the next group add the radiator and at the same time adjust the brakes, to do which the car requires to be lifted off its wheels. This is done by two large hydraulic jacks which lift the car bodily.

The chassis has now reached the end of the factory and it is placed on a turn-table and makes its way back to the far end. The next operation is to paint the chassis, and this operation is done by two men in less than three minutes. These men do not require to crawl under the chassis or even move round to paint the other side of the car. They both work from one side, while the chassis turns a broadside somersault after having been firmly clamped to a platform. The two men are armed with pistol sprays through which the paint is forced by compressed air, and while

they are working the chassis turns a very deliberate sidewise somersault.

When watching the painters at work upon a round connecting rod you may wonder what happens to the paint which misses the rod. There is an air suction lifting the air and with it the spare paint which goes up with the air.

The painted chassis then enters an oven. Between the two rails forming the track there is a rack with teeth which engage with a loose link fixed underneath the chassis. The rack does not travel, but makes a to-and-fro motion, pulling the chassis along one notch at a time. This gives it a slow progression and allows it to remain in the oven for about half an hour.

As soon as the chassis leaves the oven the temporary wheels are replaced by its own wheels, complete with tyres. It is interesting to watch the tyres being put on the rims in another section. Here we find one man who can put on a tyre with his bare hands in fifteen seconds. When motoring he need scarcely bother about spare wheels. While the wheels are being changed the car is lifted by two hydraulic jacks, a convenience we could do with on the road. When we watch this expert tyre man at work we are reminded of our copy-books at school in which we wrote *Practice makes Perfection.*

The chassis is now complete, and it is lubricated by an oil gun, and the back axle-box and the engine sump filled with oil. Water is added to the radiator, and when the tank is filled with

petrol at the pump the chassis is ready for the road. A trial body is placed on it and a test made of the chassis, and especially of the brakes. This test is made in the roads within the works, and the traffic is so great that no less than four pointsmen are on duty directing it at cross-roads.

After the chassis has been tested it is towed, in company with two or three others, to the body workshop.

In the body shop we see the wood being cut by circular saws and bandsaws which remind one of the schoolboy's fretwork, and in addition to these saws there are revolving knives, not unlike a garden mower, but not in a spiral. It is interesting to watch these revolving knives cutting the edges of the dash boards. The shape is got by means of a hardwood template which guides the wood when pressed against the revolving knife. The template comes against a fixed collar placed above the knife. There is no sawdust lying about in this workshop, it is sucked up into a large pipe which has an air fan in circuit. This sawdust is taken through the suction pipe to the furnaces where the chemical action of combustion gives sufficient heat energy to boil the water in the boilers.

When the body has been built it requires to have bolt holes made for fixing it to the chassis. The position for these is got by using a metal template which is first placed upon the chassis frame to test that the holes are all in position in it. In testing this dulls are dropped into the

holes. The template is then placed on the underside of the body and holes drilled, which are bound to correspond with those in the chassis.

The body is then painted, first with a coat of grey paint, then with whatever colour the body has to be. As already stated, the time taken to paint completely with one coat is less than two minutes.

The varnishing is done in a closed shed, the floor of which is oiled to prevent dust rising. Dust is washed out of the air by passing it through water; it is then heated.

The painted car requires to be stoved, and it passes through an oven 180 feet in length. It travels at a very slow speed on one of many tracks, being pulled along by an endless chain. There are 180 cars in the oven at one time, and remembering the inertia of the car, one would think that an electric motor of considerable horse-power would be required to move the 180 cars. We are surprised to find only a 3 horse-power electric motor, but the secret of its success is that it is geared to the chain drive 13,000 to 1.

It takes a car from four to five hours to pass through the oven, and when the car reaches the closed doors forming the exit it steps upon a large electric push and calls the attention of the attendants by ringing an alarm bell. The doors are opened and the car is withdrawn from the oven and sent round to the store from which it is to be despatched by road to its destination.

On its way out it passes through another

workshop where it is wired for the starter, the electric light, and the electric horn, and here the clock, oil gauge, switch board, and starter switch are added to the dash board.

The stock of electric wire is sufficient to make two complete waistbelts for this planet upon which we live, there being 50,000 miles of wire in stock.

The kit of tools is added, with a jack, etc., and the car is complete

CHAPTER X

CHAPTER X

HOW THE MATERIALS ARE PREPARED

THE greater part, by weight, of the motor-car is made of iron or steel, and we know that the difference between iron and steel depends upon the proportion of carbon contained in the iron.

It is well-known that iron is not found as a natural product but is prepared from iron ore, and we may speak of the manufacture of iron in the ironworks which, of course, consists in the extraction of the iron from the ore.

We have in the British Museum iron picks, hammers, knives, and saws, which were used in ancient Nineveh. The early Britons had also discovered means of extracting iron from its ore; witness the great cinder heaps in Yorkshire, which show that these early methods were imperfect, so imperfect that the residue has been used for the extraction of iron in later times, keeping twenty furnaces busy for several centuries extracting iron which the ancients failed to extract.

It was the demand for wood fuel for the manufacture of iron which caused many forests in this country to disappear, to the alarm of all

concerned; the most alarming rumours were spread as to what would happen when the wood was all used up: "There would not be left so much wood in the country as will repair one of our churches if it should fall." It was the growing scarcity of wood which led to the introduction of coal in dealing with iron ore.

Iron when extracted is brittle; metals are all of a crystalline form. In order to make the iron more useful it underwent a further process in which the combustion of wood seemed a necessity. It was not till 1785 that it was discovered that the wood could be replaced by coal. The process necessary for this was called *puddling*, and was performed in a puddling furnace, the process being the invention of Henry Cort, an ironmaster at Gosport.

Like many another inventor, he saw his fortune disappear in bringing his invention to perfection. His story may be of interest. He sought a partner and succeeded in finding one in Adam Jellicoe, a deputy paymaster in the Navy, to whom he sold an interest in his patent rights.

All went well until Jellicoe was arrested for embezzling Government funds, and as he had an interest in these patent rights, they were taken over by the Government. Poor Cort became penniless and depressed, for the Government put only a small value on the patent. However, the great ironworks of to-day stand as a monument to the value of Cort's invention, our present methods being developments of Cort's ideas, and

it will be of interest to see modern methods of preparing iron.

A good supply of air is necessary in the manufacture of iron, and for that reason the Romans built their furnaces on the tops of hills; to-day we create the necessary draught. At first this was got by a pair of bellows operated by a water-wheel, then followed the general introduction of hot-blast furnaces, invented in 1828 by James B. Neilson of Glasgow. He found that if air was heated before blown into the furnace the cost of production was lessened. He patented the hot-blast which proved a great success in practice. The burning gases of the furnace blazed forth into the night sky, and I can remember "Dixon's Blazes" in Glasgow; they have disappeared because of the closing in of the furnace tops in order to utilise the waste gases, which are drawn off and used in the heating of boilers in the works. This accounts for the clean boiler shed and the absence of coal and stokers. The steam is utilised in engines for producing the blast, a sort of cycle of events. Engines drive the blast which produces hot gases which drive the engines. There is no attempt at perpetual motion, for we have to feed the blast furnace with coal, which contains the necessary energy. When once started the furnace is kept going continuously in order to keep up the cycle of events; it is a great trouble and expense to start a blast furnace without the heat energy of the hot gases which it produces.

In working the furnace, a lift carries the material up to the top of the furnace where the charge enters; this is about 70 feet from the ground. The top of the furnace is closed by a metal cone fitting into the hole in a large iron basin, and it falls through the hole when the cone, acting as a cork, is raised by a crane. The charge of materials falls down into the hot furnace; the furnace is fed day and night. Part of the charge consists of limestone, which is added in order to render more fusible the earthy matter which is in the ore and coal. This earthy matter melts and forms the well-known slag, which floats on the white-hot molten iron which is discharged along a channel called the sow. This channel is formed in sand upon a gently sloping piece of ground. Smaller channels lead off the sow at right angles to the parent channel; there are smaller channels which are called pigs because they suggest a sow suckling her young, hence the name pig iron. We may consider the science of the blast furnace and see what actually takes place within the furnace.

The heat of the furnace is produced by the chemical action between the coal and the air, the carbon of the coal uniting with the oxygen of the air. In the ore there are iron atoms forming iron oxide, and the heat of the furnace separates the iron from the oxygen; this oxygen aids the oxygen of the air in producing the combustion. It is known generally that when the carbon of the coal and the oxygen unite they

By the courtesy of The Arrol-Johnston Co., Ltd.

AN ARROL-JOHNSTON CAR OF 1902

This strange-looking vehicle was termed a "six-seater dog-cart." As may be seen, the driver was seated in the centre, and must have found his view ahead somewhat limited when the front seat was occupied.

form carbonic acid gas, or carbon dioxide (CO_2); this is driven upwards through the material of the charge above it, the gas carrying great heat with it causing the earthy matter of the coal and ore to join hands with the limestone and form slag.

During these chemical changes some carbon atoms become attached to the iron, and there are also present some smaller quantities of phosphorus, silicon, sulphur, and manganese, so that the resulting pig iron contains all these, about 2 to 4 per cent of carbon and smaller percentages of the other elements. Ammonia is present in the hot gases produced in the blast furnace, and this is extracted, along with other by-products, which materially augment the profits of the iron works.

In the old days the pig iron was melted in an open hearth and in contact with the fuel. It was exposed to a blast of air, so that the carbon in the pig iron might be burnt out by the carbon atoms joining hands with the atoms of oxygen in the air; a pasty mass of iron was left on the hearth.

This mass was well stirred or *puddled* in order to let the oxygen atoms in the air get in contact with the carbon atoms in the iron.

When the carbon was all burnt out there was left a mass of pure iron, known as soft iron, because it was too soft for many purposes; another name is *wrought iron.* If the decarbonising process were stopped before all the carbon

was burnt out there was a small percentage of carbon left in the iron, and the amount determined the quality or properties of the metal.

If no carbon is extracted from the remelted mass it is known as *cast iron.* If less than 2 per cent of carbon is left in the iron it becomes steel, but good steel often contains very much less carbon. As already stated, it was Henry Cort who invented the puddling furnace, but since this time many improvements have been made.

An outstanding invention is the production of steel by the Bessemer process. Henry Bessemer was a civil engineer, and he was a most prolific inventor. There are shoals of patents taken out by him, and he spent somewhere about £10,000 on stamp duties alone. These were not all financial successes, but his steel process was of such great value that it raised the production in this country in a few years from 50,000 tons to 1,600,000 tons, and it reduced the cost of steel from £50 to £10 per ton. He patented his steel process in 1856, and he was knighted in 1879.

Bessemer's idea was to blow air through the molten pig iron and thus feed it with oxygen instead of merely stirring it or puddling it; he got rid of the carbon at much less cost. Bessemer's first experiments were rather alarming. The molten pig iron was poured into a cylindrical vessel, in the bottom of which were the nozzles for introducing the blast of air; this was forced through by a blowing engine. The pressure of

the air was sufficient to prevent the liquid metal from flowing through the holes of the nozzles.

The first surprise was that cold air blown through the mass should increase its temperature; it meant better chemical action, and this produced the additional heat energy. This point so impressed Bessemer that he read a paper at a meeting of the British Association for the Advancement of Science, which paper he entitled "On the manufacture of Iron and Steel without fuel"; there was fuel present in the carbon contained in the iron, and the metal had to be made molten by fuel.

The alarming part of the experiment was when a roaring flame burst forth from the cylinder with the effect of a volcano; beautifully coloured flames became an intensely white flame. The process was continued for nearly half an hour, during which time the carbon was burnt, or reduced to about 1 per cent or even to ¼ per cent.

Bessemer found it difficult to tell when to stop the burning process, but Robert Mushet suggested that the carbon should be burnt out completely and then a small percentage added. This was conveniently done by adding a little good cast iron (Spiegeleisen) containing the necessary carbon, and with this was added a small percentage of manganese.

Another process for making steel is with the Siemens-Martin furnace. In this the air is not blown through the metal, but highly heated flames play above the surface of the molten

metal contained in a shallow hearth, the bed of which is formed of infusible sand. The principle is not unlike that of the well-known blow-pipe in which the gas is mixed with a volume of air. In the Siemens-Martin furnace hot air is mixed with hot gases; there is intense combustion of the carbon in the iron. It is interesting to watch one of these furnaces at work on a dark night. It looks like a sea of gold; the white heat is so intense that one must wear blue spectacles. We watch the smelter pull a lever which opens one of the furnace doors and in he throws lumps of iron ore and occasionally a lump of limestone when he finds the slag becoming too thick. When these lumps of material fall into the furnace there is a splash of liquid gold.

The burning process is continued for several hours, then the liquid steel is run off into a large ladle carried on a trolley. It is poured into heavy moulds, thus forming steel ingots.

These ingots are converted into steel rails and angle irons such as used for the construction of the chassis of the motor-car.

The ingot has to be heated in a *soaking pit* in order to "soak" it with heat and not merely heat its surface. After about an hour's lodgment in this subterranean furnace the white-hot ingot is handed over to a *cogging mill*, which is a gigantic mangle, the rollers of which are grooved so that the metal is formed into a long square bar. This metal passes and repasses through different grooves until it emerges as a 40-foot

bar in place of a 6-foot ingot. The rough ends of the bar are cut off and squared up by means of a guillotine.

The long bar, still white hot, is then passed through a *roughing mill*, which roughens the surface to give the next machine (a rolling mill) something by which to grip it. In passing through the grooves of the rolling mill the white-hot metal takes the form of the rail or angle iron, according to the form of the grooves. The resultant rail is ten times longer than the bar which entered the rolling mill and may measure 200 feet in length. This is cut into more convenient lengths by means of large circular saws. The finished rails and angle irons are then despatched to the motor engineers.

CHAPTER XI

CHAPTER XI

A TALK ABOUT ENERGY AND HOW IT DRIVES THE CAR

A LITTLE fellow of five years surprised me by asking what energy is, and unfortunately his question could not be answered easily, as the orthodox definition of energy could not be very helpful to him. It is that energy is capacity for doing work, and we say that work is done when force is overcome through space.

The words *Energy* and *Force* have distinctive meanings in Science. Force is any cause which alters a body's state of rest or of uniform motion. We might say that the force is the power or ability of setting things in motion, but that statement would not be complete. You know that the motor-car requires the application of Force to start it into motion; even when standing upon a decline it only starts under gravitational force, but you know also that it requires the application of force to stop it. We should have perpetual motion but for the forces which stop things moving.

We have a grand demonstration of perpetual motion in the continuous motion of the planets and of the moon's motion around the earth;

there is nothing in space to stop these motions, for the æther of space offers no appreciable resistance, and there is no air to cause friction. We say a moving object possesses inertia; it is as lazy to stop moving as it is to start moving. It is not so difficult now in these days of wireless broadcasting to associate energy with the æther of space, but you may be surprised to learn that all energy resides in the æther.

You may have seen protean actors on the stage, though they are not seen so often as a generation or two ago. One actor represents several characters, changing from one to the other so rapidly that one can imagine that two of the characters appeared together. Energy is an excellent protean actor; it changes from one form to another with great ease, and it appears in many different forms.

We give Energy different names for its different forms. We speak of *Kinetic Energy*, which is the kind of energy motor-cars possess when moving. A good example of kinetic energy is that of a flying bullet. The word *kinetic* is derived from the Greek word *kineo*, meaning, I move, and all moving bodies possess kinetic energy; that is one form of energy.

Another form is called *Potential Energy*, and we have a good illustration of this in the main-spring of a watch when wound. You require to spend some physical energy in winding your watch, and the energy is stored in the coiled spring in the form of potential energy. The word

potential is derived from the Latin word *potentia*, power, and it is clear that the power driving the wheels of your watch is potential energy. We may call it the energy of position, and we might subdivide it; for instance, we might speak of *gravitational energy* which pulls a motor-car downhill and holds it to the surface of the Earth while we fly through space at a prodigious speed (1000 miles a minute). Again, a raised clock weight demonstrates potential energy, and a moving pendulum possesses kinetic energy and potential energy alternately. As we watch it swing to and fro we witness a transformation of energy. At one moment it possesses the energy of motion (kinetic energy), but gravitational force stops it moving, and at the moment when it has reached the furthest point it possesses the energy of position (potential energy), which is again transformed into kinetic energy, and so on it goes with its alternate changes.

We have many evidences of one body transferring energy to another. The footballer's foot, when in action, possesses kinetic energy, and he transfers this to the football; he has to overcome the inertia of the football, but having set it in motion, it will continue moving until some force stops it. Another player may apply the force, but if not, the wind may help, and in any case gravity plays a constant part. We sometimes see a quickly moving billiard ball transfer all its kinetic energy to another ball.

People sometimes forget that there is a loss of energy when it is transferred and when it is transformed. No energy is destroyed, and in the case of the billiard ball the kinetic energy which is lost appears as heat, and then disappears into a latent form in which it has gone beyond our control. But what is *Heat Energy?*

Heat energy is due to the motion of particles or molecules of matter. When a body is heated its molecules are set into a state of rapid vibration. When we heat a piece of metal we may cause its molecules to vibrate till they lose their firm hold upon one another, and the metal becomes a liquid. We may increase the vibrating motion till the liquid is vaporised or becomes gas, but a better demonstration is that of boiling water. When we boil water we produce steam, which is an invisible gas, and in which the molecules have so far lost their hold on one another that they are moving about, and so colliding with one another that they spread out into any space available; we require to have a containing wall. If the heat energy is great, as is the case with steam, we require a very strong wall to hold the steam; it is the pressure exerted by the colliding particles which drives our steam engines.

We have a grand demonstration of heat energy in the Sun, and we know how this energy is transferred to the earth by æther waves of the same nature as wireless waves but much more frequent, of a higher frequency. The energy

contained in the Sun is enormous; the temperature is measured in millions of degrees.

It is heat energy which drives a motor-car, whether it be steam or petrol. When thinking of the loss of energy in transformation I am reminded of a letter which I received some years ago from a correspondent, who informed me that he had an idea which he desired to patent and upon which he would like some advice. I replied that I was not a trained engineer but that I would be very pleased to consider his problem from the scientific side if that would serve his purpose. In due course I received his plans, which were the following:

An internal combustion engine was to drive a dynamo which was to supply electric current to decompose water, breaking it up into its components, oxygen and hydrogen. The hydrogen was to be passed along to the engine and exploded with a mixture of air, and the engine, as well as driving the dynamo, was to drive other machines.

I pointed out to him that his plan if workable would give perpetual motion, which is out of the question as long as we have the force of friction. I also pointed out that he was overlooking the loss of energy at each transformation, and that because of this loss he would not have sufficient power to drive his engine, let alone the machinery. It is sometimes difficult to dissuade an inventor from a plan which is clearly impracticable, but I am pleased to say that this correspondent wrote that he was abandoning his idea, which he had

harboured for five years, and that he now saw that the thing was impossible.

In the *Romance of Coal* I told of a man who informed me that he had an engine which would go without power, and I pointed out that we cannot get energy from nothing, but only by transforming it from one kind to another. A reader wrote to me informing me that I was mistaken, for he had invented an engine which would go without power, and he was about to leave the army in order to be free to patent his idea. The statement in the book had evidently shaken his confidence a little, for he said he would like to submit his idea to me in confidence before he resigned his position.

The plan was to have an accumulator, which my correspondent failed to notice was a source of power. The electric current from the accumulator drove an electric motor, which in turn drove a dynamo, and the electric current from the dynamo recharged the accumulator: another case of apparent perpetual motion. When the loss of energy at each transformation was pointed out, the correspondent was most grateful and decided not to resign. In the plan proposed by this correspondent we see the chemical energy of the accumulator transformed into electrical energy, which is converted into mechanical energy by the motor, which energy again is converted into electrical energy by the dynamo.

As already stated, all energy resides in the æther, which at first seems surprising, but let us

take an example. When we bring a magnet towards a compass needle the needle moves long before the magnet comes in contact with it; we say there is a magnetic field surrounding the magnet. (The word field is used in Science in the same way as we speak of a potato field—an area containing something.) This field still exists when we place the magnet in a vacuum so that it does not reside in the air; the only place in which this field of energy can reside is the æther. Again, let us think of a simple needle telegraph in which a magnetic needle moves within a coil of wire when an electric current passes through the wire. The needle does not come in contact with the wire, but the electro-magnetic field controls the little magnet; again, the energy must reside in the æther surrounding the wire. We know that chemical energy depends on the attraction of one atom upon another, and we know that these atoms never come in contact with one another; they are linked together by the æther in which the chemical energy resides. The case of the atoms is the same as the attraction between two similarly electrified bodies: chemical affinity is electrical attraction. We shall see in the chapter dealing with electricity that the atoms are composed entirely of electricity.

While I have mentioned the names of several forms of energy, it will be observed that all these fall within one or other of two classes, kinetic and potential.

We hold a heavy weight over a piece of iron on an anvil; there is potential energy residing in the æther surrounding the weight, we call it gravitational energy: it is potential energy. When we lift the weight from the earth we strain the æther. When we let go the weight the earth pulls it down and the weight strikes the piece of iron, and from what has been said already it is evident that the energy is transformed into heat energy, by setting the molecules of the iron into a state of vibratory motion, which we classify as kinetic energy. The heat disappears and becomes latent and it is ungetatable. It is radiated away, and Sir Oliver Lodge has suggested that this disappearing energy, upon reaching the confines of space, may serve to create matter.

Did you ever puzzle over the fact that the water in the radiator of your car, say, if the fan is not working and the engine has hard work, may reach the temperature of 212 degrees Fahrenheit, but can never reach a higher temperature. At this temperature the molecules' cohesive energy is overcome by the heat energy and the molecules of water let go their hold upon one another and escape into the air in the form of the gas *steam*; the potential energy of molecular straining is converted into kinetic movements by the vibrating molecules. In other words, at 212 degrees the heat energy transforms the liquid water into steam. The water cannot remain liquid at more than 212 degrees unless subjected

to more than atmospheric pressure, whereupon it may become superheated.

I heard a sermon addressed to the boys and girls of a congregation, in which the preacher said that he had boarded a tramway car a few days previously and had suddenly left it. Why?

Because he found that he only had a halfpenny in his pocket, and yet he had been reading a few days previously that a halfpenny contained enough energy to carry a goods train round the world. He referred, of course, to the energy of moving particles of electricity locked up within the atoms. We believe the atom to contain kinetic energy, though there is a static model in which the energy is supposed to reside in the potential form.

In any case, when a radium atom explodes it radiates energy in three forms, which we call *alpha*, *beta*, and *gamma rays*. The alpha rays are a stream of flying atoms of the element helium, and the beta rays are a stream of flying particles of negative electricity (electrons), while the gamma rays consist of a wave of motion in the æther of space (X-rays).

Before passing on to consider how the energy drives the car we might consider the vapourising of petrol. It is well known that petrol vapourises at ordinary temperatures; *it is volatile;* its molecules escape into the air. This action is greatly facilitated by the application of heat, hence the engine is more easily started when it is warm.

When the petrol does vaporise there is a drop in the temperature due to evaporation. This chilling effect may be felt by placing a little petrol on the hand and allowing it to evaporate. Evaporation from wet clothes may produce a chill, and it is quite a wise plan to put a dry garment over the wet one to prevent evaporation.

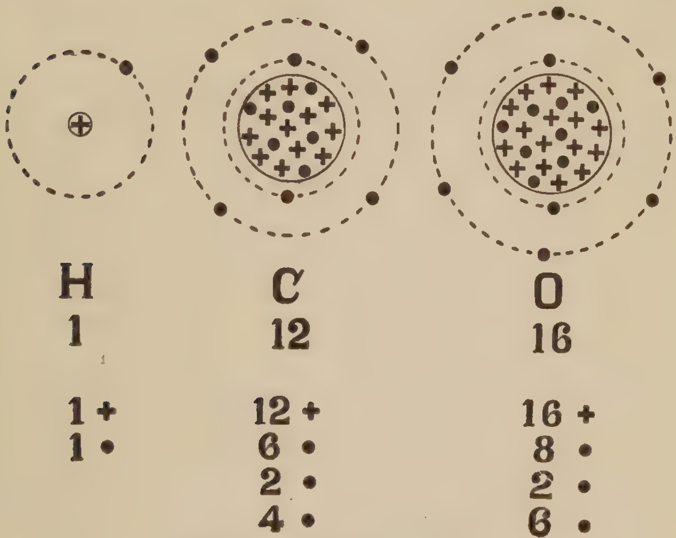
HOW ENERGY DRIVES THE CAR

It is quite evident that it is the energy of the exploding gas mixture which drives the car, but we wish to consider what the explosion means. This takes us into the field of chemistry as well as physics, and to understand the chemical side clearly we must consider the construction of matter, Chemistry being the Science which investigates the properties of the elements of which substances are composed: the actions of atoms. On the other hand, Physics investigates the construction of these atoms.

We know that the atoms are composed of particles of positive and negative electricities, but how are these arranged? We don't know; we can only speculate.

The diagram on page 155 represents our present ideas. The dots in the diagram represent *electrons*, and the + sign represents the positive particles or *protons*. It will be observed that there are equal numbers of electrons and protons within the atom, and that the different atoms are comprised of different collections of particles

differently arranged. The simplest atom is that of the lightest substance—hydrogen. The atom of hydrogen is not gas, it is merely a collection of positive and negative electricities. Two of these atoms go to form a molecule of hydrogen, and a myriad of these in a violent state of motion form the gas hydrogen.



Modern Pictures of Atoms.

Those of us who have taken any interest in chemistry know that the chemical symbol for water is H_2O, signifying that a molecule of water is composed of two atoms of hydrogen and one atom of oxygen, linked together by chemical union or electrical attraction; but how does this attraction come about? The electron revolving around the positive nucleus of the hydrogen atom

passes over to the atom of oxygen, which can accept it and thereby become more stable; but this transference upsets the electrical balance of the atom, one being positively electrified by the absence of an electron and the other being negatively charged by the addition of the electron, hence the attraction of oppositely electrified bodies, hence the chemical union.

We may form water by placing a quantity of hydrogen and oxygen atoms together in a strong bottle. When we place them together they immediately become well mixed owing to the rapid motion of their particles, but they do not unite. It requires the energy of an explosion to unite them. When we explode the gas mixture they unite and form water, which appears in a minute quantity on the walls of the bottle.

We explode the mixture of petrol vapour and air in the cylinders of the motor-car to cause a chemical change, but petrol and air do not form water, they form other gases. It is obvious that the molecules break up and that there is a "general post" among the atoms. The collisions in the general post are so great that much heat is developed so that the gases expand and occupy much more space, hence they push the piston head along the cylinder in order to get more room. An explosion is just a very sudden chemical change. We know that the atoms are crowded together by the compression stroke at the moment the gas mixture is exploded by the electric spark. Then comes the sudden expansion producing the

movement of the piston, which now possesses kinetic energy which it stores in the revolving flywheel by overcoming its inertia. This store of energy drives the piston upward again so that it drives out the burnt gases, and, still moving under the momentum of the flywheel, it moves downwards, sucking in a fresh supply of gas and air, then more energy from the flywheel moves it upwards again, compressing the gas mixture. When we advance or retard the spark we cause the explosion to take place earlier, or later when the compression is not so great, and by which means we get a softer explosion with consequently less power.

Before passing on to consider electricity and the electrical equipment in the succeeding chapter, it may be of interest to enquire into the meaning of horse-power.

Power is the ability to do work, and the term horse-power was introduced by James Watt in order to compare the work that could be done by his engine with that of horses. Horses had been used in working the water pumps in coal mines, and the steam or atmospheric engine had been invented by Newcomen to work these pumps. Watt ascertained with some accuracy the average power of a horse. A horse could raise a weight of 150 lbs. (against gravity) at the rate of 220 feet per minute. By simple arithmetic this is equivalent to raising 33,000 lbs. one foot in one minute; so we say that one horse-power is necessary to raise 33,000 foot pounds per minute.

Watt said that a horse could exert this power during an eight-hour working day, but he over-estimated the power by about $33\frac{1}{3}$ per cent. Later estimates give one horse-power as equivalent to 22,000 foot pounds per minute. Of course a horse could exert a greater power for a shorter period.

Motorists know that the power of a motor-car is now determined by the bore of the cylinder and the length of the piston stroke. In connection with the term *brake horse-power* it is interesting to note that the pulling power of a motor-car was determined by opposing a resistance to the wheels till the engine stopped.

This reminds me of an incident which happened some little time ago.

A motorist by the roadside appealed to me for assistance, his trouble being that his brakes had become heated through his running for some time with the brakes on. I thought at first that this had been, as one would suppose, accidental, but later I thought differently. The motorist asked rather anxiously if he could return to So-and-so without turning, which proclaimed him to be a novice. On starting up his engine it went off at a 50 miles per hour rate, and when I asked him to take his foot off the accelerator he said it was not on. Then I asked him to throttle down the engine; he was at a loss to know what to do as the car had no lever control. I then suggested that he should turn off his petrol supply, and he knew where the stop cock for this was. He

seemed quite surprised when the engine began to throb at a reasonable rate, and from his remark, "That's what's been wrong," I came to think that he was running with the brakes on in order to reduce the speed of travel. We now pass on to consider the science of the electrical equipment.

CHAPTER XII

CHAPTER XII

ELECTRICITY AND THE ELECTRICAL EQUIPMENT

IT was a long step (2000 years) from rubbed amber to electrical machines. It was a shorter step (200 years) from the electric charge of these machines to the discovery of the electric current in Volta's battery in 1800. It was a still shorter step (30 years) to the discovery of the principle of the dynamo by Michael Faraday in 1831, which became a practical self-exciting machine in 1870.

In passing, it may be of interest to consider the difference between an electric charge and an electric current, and in doing so we must first picture the present-day construction of matter. All substances are composed of atoms, which are not specks of matter but are composed entirely of positive and negative electricities, whatever these may be. It is thought that they may be entanglements of the æther of space.

I wish to define our position as we go along, so we must consider this mysterious æther. We have no idea as to its nature, but we know that it is not any form of matter. We believe it to be the stuff of which matter is made, the nothingness out of which the world was created.

The æther offers no resistance to matter moving in it. This planet upon which we live is carrying us through the æther at a speed which beats all motor records; we are travelling through space in an orbit around the sun at a speed of 1000 miles per minute. If the æther offered any appreciable resistance to our movement we should lose the flimsy blanket of air which we are carrying with us, and this would happen much more easily than the dislodgment of some light article in the case of a motor-car moving through the air.

We see that it is hopeless to try to disturb the æther by any motion of material things, but the æther is disturbed by the motion of particles of electricity: hence the æther waves in wireless telegraphy and telephony. Our present interest lies in the constitution of matter.

It has been proved that the atoms are composed of particles of positive and negative electricity, and we have very simple proofs of the existence of these two kinds of electricity. We can easily show that the electricity on a rubbed rod of glass is different from that of a rubbed vulcanite rod. If we electrify two objects with charges from the same source we find they repel one another.

You may be able to demonstrate this with the handle of a fountain pen and a small piece of paper. If you rub the fountain pen on your sleeve it will have no difficulty in attracting a small piece of paper, which will cling to it. Then lay the piece of paper upon any insulator, a glass

ink bottle, a tumbler, or a flower vase will serve the purpose. Then electrify it in the same way as before, and you will be able to demonstrate repulsion between the two similarly electrified bodies : the paper will no longer cling to the pen.

But a better experiment is to electrify a pith ball, or a feather, or a piece of paper suspended by a silk thread from any insulator, such as a rod of glass. If we electrify the ball by contact with a glass rod which has been rubbed, the ball will be repelled by the glass rod, while it will be attracted by a rubbed vulcanite rod. We say that opposite electricities attract ; we are satisfied that there are two different kinds of electricity, which we may call vitreous (glass) and resinous, or we may recognise them by the names positive and negative electricities.

What really happens is this. When the glass rod is rubbed by a silk cloth particles of negative electricity (electrons) are rubbed off the glass and are transferred to the silk handkerchief, making their escape to the great reservoir in the earth. This leaves the glass with a preponderance of positive electricity, the two electricities having been balanced in the undisturbed condition. Had the escape of the electrons from the silk been cut off by an insulating substance the silk would have contained the surplus of electrons, which would have rendered it negatively charged.

In the case of the vulcanite rod when rubbed with, say, a catskin, electrons leave the catskin and attach themselves to the vulcanite rod,

producing a negative charge, due to the surplus of electrons. That is the meaning of an electric charge.

Again, in a piece of metal there is a myriad of free electrons capable of moving from atom to atom, and when we connect the wire to the two terminals of an electric battery these electrons make a steady march from atom to atom along the conductor. They do not carry the energy through the conductor but through the surrounding æther of space, which is disturbed by their movement. What I have described is called a direct continuous electric current. In the dynamo or the magneto the electrons are caused to vibrate in the armature, and in doing so they make no regular procession; it is merely a to-and-fro motion from atom to atom. We call this an alternating electric current. We may lead out this alternating current to the outer circuit, or we may convert it into a direct or continuous current by means of a commutator placed on the revolving armature.

I have referred to Faraday's discovery of the principle of the dynamo. What he discovered was that when he caused a wire to move in the magnetic field produced by a magnet there was a to-and-fro current produced in the wire. Simple electro-magnetic machines were made in which a coil of wire was caused to rotate in a magnetic field, and the foundations of the dynamo were laid, although it took forty years to evolve a practical self-exciting dynamo.

By *self-exciting* is meant producing an electric current for its electro-magnet or field-magnet, between the poles of which the armature revolves. The electro-magnet had been invented in 1825 by a London surgeon, William Sturgeon, and it consists of a piece of soft iron surrounded by a coil of insulated wire through which a direct current of electricity passes around the magnet. The magnetic field will only exist so long as an electric current flows in the surrounding coil. There is always sufficient residual magnetism left in the iron to produce a weak magnetic field, and this sets up a weak electric current, part of which goes to energise the revolving coil, and this passes to the field-magnet and so on.

The dynamo for the electric lighting system, etc., has an electro-magnet, but in the magneto it is sufficient to use a set of permanent steel magnets of the horseshoe type. I have a large permanent steel magnet which I bought when I was a schoolboy and it is still very active; they are only permanent if not roughly handled.

In most cars the dynamo serves also as a motor for starting the engine. This reversibility was discovered by Gramme in 1871. In the dynamo we supply mechanical motion and transform it into electrical energy, as already explained under Energy, and in the motor we supply an electric current and obtain mechanical motion. The electric horn contains a miniature motor, getting its current from the accumulator, as do the lamps and the motor starter also.

What happens in the accumulator is this. The progression of electrons from the dynamo, or in other words the electric current, in passing through the lead *grids* of the accumulator, produces a chemical change, the reaction of which produces an electric current.

On one occasion I overheard two workmen discussing electrical matters, and it was evident from the conversation that one of the men was employed in an electric supply station. His friend twitted him with not knowing what electricity was, but to my astonishment the accused said he did know, and when challenged to explain, he said that it was composed of lead and sulphuric acid.

The electric lamps have been evolved from a very simple discovery made by Humphry Davy, when he was a professor in the Royal Institution, London. It was in 1806, which was before the invention of the dynamo. He had a large battery of 2000 cells, and on bringing together the wires from the two terminals he produced a flame which melted the ends of the wires. To prevent any melting he fixed two carbon pencils to the ends of the wires, and on bringing these together and then separating them he produced a beautiful flame of light. He happened to place the carbons horizontally, and the hot air rising from between the white-hot points of the carbon carried the flame upwards so that it formed an arch or arc, hence the arc light.

Electric lighting was out of the question as

long as the only source of current was primary batteries. As is well known to you, the accumulator is dependent upon the dynamo. Edison and Swan made an electric glow lamp. At first they tried a metal wire but without success, but they succeeded with a carbonised strip of bamboo or a cotton thread carbonised. These filaments offer so much resistance to the passage of the electric current that they become white hot. At a later date it was discovered that a very fine wire of ossmium or some other metals would become incandescent and yet remain unmelted, and the advantage of the wire filament is that it only requires about one half of the current necessary for carbon lamps to render the wire incandescent. The filament must of course be placed in a vacuum, or in a gas which has no affinity for the metal, otherwise there would be combustion.

In working with the electrical equipment one soon realises that a complete circuit is necessary before the electric current will flow. There is no mystery about the subject of the complete circuit. We may picture a zinc and carbon battery passing along electrons under the chemical energy of the battery. The electron drift is from the carbon to the zinc within the solution in the cell, and therefore from the zinc to the carbon through the outside circuit. We speak of this as the negative current, as the older idea was to think of a positive current from the carbon to the zinc. The present interest lies in the fact that this electron current cannot pass from the zinc to the

carbon unless there is a complete circuit; any break in the circuit makes the current impossible; it cannot be otherwise unless we supply sufficient energy to shoot the electrons across, as we do in the engine plugs, to produce a spark. To shoot electrons across a glass tube more easily we may remove the air, or as much of it as we can. Instead of a spark we get a silent discharge accompanied with a glow, as we see in some forms of spark testers, the action of the magnet being judged by the glow in a small glass tube mounted in a wooden holder. Much of the scientific knowledge concerning the construction of matter has come to us through the behaviour of the electric discharges through vacuum tubes, but that is outside the scope of the present book.

It may be of interest to sum up the whole matter in the succeeding chapter.

CHAPTER XIII

CHAPTER XIII

THE CONCLUSION OF THE WHOLE MATTER

WE have seen how power came into man's hands by his taking advantage of the energy of wind, running water, gravitation, and the expansion of steam, the energy of these being due to motion. We have seen that there were many attempts at mechanical propulsion before the pedigree of the motor-car commences; the real start is from Cugnot's steam carriage in 1769.

We are not surprised that those interested in railways, and also the road trustees, were sufficiently strong to kill the early steam carriages by exorbitant tolls and by molesting the vehicles by placing obstacles on the roads; we have seen *wire pulling* in our own days.

We regret that Parliament allowed a restriction of speed to 4 miles per hour to delay the coming of the motor-car, whereas the Act and the Red Flag should have been applied only to traction engines.

We have traced the evolution of the petrol motor from Huyghen's gunpowder engine to gas engines, and we have seen how the motor industry began on the Continent and later in this country. Races, contests, and roads have assisted in the

advancement of the motor-car, which is now being turned out somewhere at the rate of 1100 per week by one British firm.

From the description of the state of the roads in the days of our great-grandfathers we should have feelings of gratitude for present conditions. I apologised to an Australian on one occasion for taking him over a bad road, to which he responded "I wish we had a few bad roads in Australia."

That we owe much to the pioneer motorists is evident from a remark made by Lord Montagu of Beaulieu: "I well remember in those early days the amount of persecution and abuse which the motorists had to encounter. Among our friends we were considered mad. In the Press we were held up to public derision, sometimes as fools, sometimes as knaves, and every accident that happened, even remotely connected with the motor-car, was attributed to the new 'juggernaut' as it was called. It is curious also, now in these days, when the Press is so favourable to the development of automobilism, to recall that in those early times the daily and weekly papers were almost without exception hostile."

In considering the science of the motor-car we have made excursions into the subject of Energy, and we have seen how it is transferred and transformed, and how the exploding gases drive the car.

The consideration of the electrical equipment

has led us through some of the science relating to the chemical and physical properties of matter. The difficulty has been not to let one thing lead to another until we get far beyond the original subject. The field is so large I have tried to avoid taking any reader beyond his or her depth, believing that success lies that way. It is easy to go too far, hence I conclude this volume here.

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